BOSTON PUBLIC LIBRARY
3 9999 06544 684 9

Public Document No. 147

The Commonwealth of Massachusetts

6457

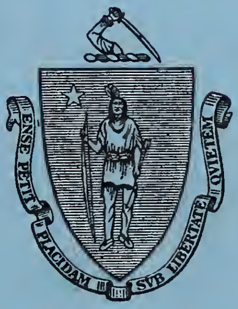
ANNUAL REPORT

OF THE

METROPOLITAN DISTRICT WATER SUPPLY COMMISSION

FOR THE

YEAR ENDING NOVEMBER 30, 1935



PUBLICATION OF THIS DOCUMENT APPROVED BY THE COMMISSION ON ADMINISTRATION AND FINANCE

1500. 2-'36. No. 9793

REPORT OF THE METROPOLITAN DISTRICT WATER SUPPLY COMMISSION

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan District Water Supply Commission, established under the provisions of Chapter 375 of the Acts of 1926, respectfully presents for the year ending November 30, 1935, its

TENTH ANNUAL REPORT

I. Organization and Administration

Eugene C. Hultman, of Boston, succeeded Davis B. Keniston as Chairman of the Commission on December 27, 1934. Charles M. Davenport and Thomas D. Lavelle, both of Boston, continued during the year as Associate Commissioners. R. Nelson Molt continued as Secretary.

The clerical force of the Commission's office at Boston remained substantially the same throughout the year. Three special agents under the direction of the Commission continued to care for the property acquired by the Commission in the Swift River and Ware River areas. Real estate purchasing agents and conveyancers and other experts were employed as needed. The engineering and clerical force of the engineering department averaged 146 employees during the year. The maximum number employed at any one time by contractors on the various construction projects during the year was 698 persons. From time to time temporary local laborers were employed by the Commission for the removal of bodies and in miscellaneous work of maintenance.

The Commission continued, through duly appointed agents, the direction of the town government of the Town of Prescott, as provided by Chapter 340 of the Acts of 1928. A financial statement for the town is included in the Commission's report to the Commissioner of Corporations and Taxation.

II. Engineering Department

Frank E. Winsor continued as Chief Engineer, Karl R. Kennison as Assistant Chief Engineer, and Walton H. Sears as Mechanical Engineer.

The field divisions continued as follows: Quabbin Reservoir Division at Enfield, Mass., in charge of N. Leroy Hammond; Coldbrook-Swift Tunnel Division of Quabbin Reservoir until its discontinuance October 31, in charge of Richard R. Bradbury; Dam and Aqueduct Division in charge of William W. Peabody.

Charles T. Main, Inc., of Boston, was employed from time to time as a general consultant on mill and water power damages and also on the design of the dam and dike of Quabbin Reservoir. Dr. Charles P. Berkey of Columbia University continued as consulting geologist. Other consultants were employed from time to time as needed.

The Commission regrets to report the death on August 10 of Mr. X. H. Goodnough. By the death of Mr. Goodnough the Commission lost the services of one who was particularly well fitted to advise them on this project. Mr. Goodnough devoted a lifetime to the service of the state. He was born in Brookline, Massachusetts, in 1861. Shortly after graduating from Harvard University and obtaining a variety of experience in engineering work, he was employed by the State Board of Health in various capacities. He was Chief Engineer of the Board, later the State Board of Health, for 35 years previous to his retirement in 1930. Under his direction the department developed into one of the most important agencies of the state for the protection of the public health and the development and conservation of its resources. He acted as Chief Engineer of the Joint Board to investigate water supply needs and resources of the State, which investigation led to the present extension of the water supply sources of the Metropolitan District to the Ware and Swift rivers.

III. Offices

The office of the Commission and of the Chief Engineer continued on the ninth floor of the Metropolitan District Commission Building at 20 Somerset

Street, Boston. The only change in the offices of the Commission was the discontinuance of the Coldbrook-Swift Tunnel Division of Quabbin Aqueduct on October 31. The laboratories for water analysis and soil testing were continued at Enfield.

IV. Real Estate and Water Rights

The Commission, for reservoir purposes, has acquired a total of approximately 63,504 acres of land in the Swift River watershed, and for sanitary protection and construction purposes in the Ware River watershed a total of about 6,195 acres.

The exceptions taken to the Supreme Judicial Court by the Commission to the report in the petition of Maher and Duggan brought by Thomas F. Maher and John J. Duggan under the provisions of Section 5 of Chapter 321 of the Acts of 1927 which report awarded $221,000 for land owned by the petitioners in Greenwich and necessary for reservoir purposes was heard and the Supreme Judicial Court sustained the exceptions and the Commission has petitioned for a new board of referees to rehear the petition.

Upon petitions of the selectmen of the towns of Ware and Enfield, the so-called river road from the Ware-Belchertown highway south of the main dam, northerly through the valley to its intersection with the highway leading from Belchertown to the village of Enfield was discontinued as a public way by the County Commissioners of Hampshire County on August 13. This, together with the previous abandonment of the Athol Branch of the Boston and Albany Railroad, cleared the way for the construction of the main dam. The last passenger train on the Athol Branch of the Boston and Albany Railroad ran on June 1.

As a result of the opinion of the Attorney General given to His Excellency the Governor and Honorable Council, the Commission was required in August to submit to the Honorable Governor and Council for approval settlement of all claims and to secure the approval of all new projects prior to their acceptance by the Commission.

V. Ware River Supply

Agreements were completed with the United States Veterans Administration and the State Department of Public Health covering the connections of the sewers of their hospitals in Rutland and the use of the Rutland-Holden trunk sewer for the diversion of the sewage to the Worcester sewerage system. This trunk sewer was operated throughout the year.

The temporary chlorinating plant in the upper watershed of the Ware River was operated on November 30.

Water was diverted from the Ware River three days in January, seven days in February and two days in March.

VI. Swift River Supply

Real estate and topographic surveys were continued during the year. Some reforestation of the areas of Quabbin Reservoir above the flow line was instituted.

The Wenzel and Henoch Construction Company completed on October 1 the work under Contract 20 for the construction of the Coldbrook-Swift section of the Quabbin Aqueduct, thus completing the 24.6 miles of aqueduct between the west end of the Wachusett Reservoir and Quabbin Reservoir in the Swift River Valley.

The remainder of the construction of a highway west of the reservoir site about 21 miles long from Belchertown to a point on the road between North Dana and Orange just north of the Orange town line was completed and taken over by the Department of Public Works as a state highway. This highway has been named "Daniel Shays Highway" commemorating a local historic event of national importance, namely, Daniel Shays's Rebellion in 1787, Daniel Shays himself owning a farm in what is now the town of Prescott and leading a group of men, drilled on Pelham Common, on the arsenal at Springfield, where they were dispersed by State Militia and fled through Amherst and Prescott to Petersham, where they were finally captured.

Contract 38 was awarded on May 9 to C. J. Maney Company, Inc., Boston, and B. Perini & Sons, Inc., Framingham, operating as The Two Companies, Inc., for constructing a core wall to sound rock at the site of the main dam of Quabbin Reservoir in the towns of Belchertown, Enfield and Ware. Work has been in progress under this contract, the open trench across the valley, about 25 feet below the level of the Swift River, being completed and the caisson core wall substantially completed. There are in all 40 caissons across the valley. Thirty-five of these have been sunk to bedrock and sealed. Of the remaining 5, 2 are in the process of sealing and 3 are practically down to bedrock.

Contract 49 was awarded on October 1 to Cenedella & Company, Milford, Mass., for excavating diversion channels at the site of Quabbin Reservoir, one at the lower intake to Quabbin Aqueduct, one at the outlet from Shaft 11A, and one across the divide between the East and Middle Branches of Quabbin Reservoir. Work has been in progress under this contract.

The Arthur A. Johnson Corporation continued under Contract 50 for constructing the embankment of the dike of Quabbin Reservoir. The foundation embankments have been completed along both upstream and downstream toes and the work is in progress on the hydraulic sluicing of the main embankment.

VII. General

The engineering force continued its studies of the development of hydroelectric power at various points on the work. No electric power development is practicable until the completion of Quabbin Reservoir provides the necessary storage of water.

Plans are being made for the general reforestation of areas purchased by the Commission except those located below the flow line of Quabbin Reservoir. An experimental nursery was established in the Town of Greenwich and planting of seedling conifers was commenced in cleared areas on the "Prescott Peninsula."

Permission was granted for the construction on land of the Commonwealth in Belchertown of a camp for the Civilian Conservation Corps. This camp is located just south of the Ware-Belchertown Highway and about one-half mile west of the Swift River. Permission was also granted for the construction by the Emergency Relief Administration of miscellaneous water holes to be used for fire protection.

VIII. Cemeteries

The Commission has continued the assignment of lots in the new Quabbin Park Cemetery and 553 bodies were removed from the Quabbin Reservoir area during the year, of which 514 have been interred in Quabbin Park Cemetery. To date a total of 2,465 bodies has been removed from the Quabbin Reservoir area, and there have been 71 original burials in this cemetery.

IX. Financial

The Commission appends hereto a statement of its expenditures and disbursements for the fiscal year, and from the date of its appointment.

X. Other Reports

The report of the Chief Engineer is herewith presented. It includes a report on the geology of the region in which the Commission's operations have been conducted.

XI. Recommendation

As it is doubtful that the provisions of Section 9 of Chapter 321 of the Acts of 1927 are broad enough to authorize the Treasurer and Receiver General to receive and invest funds for the perpetual care of lots in Quabbin Park Cemetery established by the Commission, it is recommended that a special resolve which the Commission has filed be passed substantially in the form submitted herewith.

Respectfully submitted,
E. C. HULTMAN, *Chairman.*
CHARLES M. DAVENPORT, *Associate Commissioner.*
THOMAS D. LAVELLE, *Associate Commissioner.*

20 Somerset Street, Boston, Mass.
January 15, 1936.

RESOLVE TO AUTHORIZE THE TREASURER AND RECEIVER-GENERAL TO RECEIVE AND INVEST FUNDS FOR THE PERPETUAL CARE OF LOTS IN QUABBIN PARK CEMETERY, WARE, MASSACHUSETTS.

Resolved, that the Treasurer and Receiver-General of the Commonwealth of Massachusetts be and hereby is authorized to receive, hold and invest such funds as may be paid to him from time to time by the Metropolitan District Water Supply Commission or by others, for the perpetual care of cemetery lots originally or relocated in Quabbin Park Cemetery, as a special fund entitled "Perpetual Care of Lots in Quabbin Park Cemetery, Ware, Massachusetts."

Resolved, that the Treasurer and Receiver-General be and hereby is authorized upon the completion or transfer of Quabbin Park Cemetery to pay such fund together with any accumulations thereon to such trustees, persons, or municipality, or to the Town of Ware, or to its officials charged with the care of cemeteries, to whom Quabbin Park Cemetery upon its completion shall be transferred by the Metropolitan District Water Supply Commission.

REPORT OF THE CHIEF ENGINEER

To the Metropolitan District Water Supply Commission.

Gentlemen:—The following is a report of the engineering department for the year ending November 30, 1935.

Organization

The engineering organization has been decreased about 14 per cent in number during the year.

Karl R. Kennison, Assistant Chief Engineer, continued in charge of all studies in connection with the general plan of the work and the design of structures, preparation of contract specifications, contract and working drawings.

Charles L. Coburn and Stanley M. Dore, Assistant Designing Engineers until November 1 and since then Associate Civil Engineers, continued their general supervision of the detailed work of the office; and Walton H. Sears, Mechanical Engineer, continued in charge of the collection of data in connection with mill and water power damages. They have assisted in the preparation of contract specifications.

Three division engineers continued in charge of field divisions as follows: William W. Peabody, Dam and Aqueduct Division until November 4 and thereafter the Quabbin Aqueduct Division; Richard R. Bradbury, Coldbrook-Swift Tunnel Division until its discontinuance October 31; N. LeRoy Hammond, Quabbin Reservoir Division.

X. Henry Goodnough, Inc., continued as consulting engineer until Mr. Goodnough's death on August 10. Charles T. Main, consulting engineer of Boston, Dr. Charles P. Berkey, geologist of Columbia University and other experts were employed from time to time.

The assignment of employees under the direction of the Chief Engineer at the end of the year and of the preceding year was as follows:

	Nov. 30, 1934	Nov. 30 1935
Headquarters Office, Designing Division	39	39
Main Dam Core Wall Office	—	27
West Ware Office, Dam and Aqueduct Division	19	—
Coldbrook Office, Quabbin Aqueduct Division	—	14
Hardwick Office, Coldbrook-Swift Tunnel Division	40	—
Enfield Office, Quabbin Reservoir Division	61	57
Total Engineering Force	159	137

The maximum force during the year was 159, during the four weeks ending December 29, 1934. The minimum force was 137, during the three weeks ending November 30. The average force for the year was 146.

Offices

The office of the Chief Engineer and Designing Division was continued in the Metropolitan District Commission Building at 20 Somerset Street, Boston. The office of the Dam and Aqueduct Division was continued at the site of the main dam of Quabbin Reservoir in West Ware until November 4, when the work of sinking the caissons for the main dam core wall was nearly completed and this division was superseded by the Quabbin Aqueduct Division. The office of the Coldbrook-Swift Tunnel Division was continued in the brick building formerly used as a school at Hardwick Center until October 31, when this division was discontinued. On November 4 the Quabbin Aqueduct Division was established with an office in the Ware River intake building in Coldbrook, and with a branch office at Shaft 12 of Quabbin Aqueduct in a building formerly used as a field office during the construction of the Coldbrook-Swift Tunnel. The office at the site of the main dam continued to be occupied by the force engaged upon the completion of the caisson core wall, this force after November 4 being in charge of Senior Civil Engineer Frederick W. Gow. The office of the Quabbin Reservoir Division was continued in the property of the Commonwealth formerly known as the Frances W. Chandler house on Quabbin Road, and the laboratories for water analysis and for soil testing were continued in the property of the Commonwealth formerly known as the Barlow house in Enfield.

HEADQUARTERS OFFICE

Summary of the Year's Work

Real Estate.—Reports and recommendations with respect to the purchase of real estate in the Quabbin Reservoir area were submitted to the Commission during the year covering 3,966 acres, making a total reported on to date of 79,199 acres.

PROGRESS OF REAL ESTATE PURCHASES FOR QUABBIN RESERVOIR

	Total Area Negotiated Including Owners' Offers to Sell to Commonwealth (Acres)	Title Vested in Commonwealth (Acres)
Total for year ending Nov. 30, 1935 . . .	3,966	4,304*
Total to Nov. 30, 1934	75,233	59,200
Total to Nov. 30, 1935	79,199**	63,504

Options outstanding Nov. 30, 1935, include 1,509 acres.

* Includes some offered in previous years.

** Includes 6,336 acres not required.

Reports and recommendations were also made with respect to the purchase of real estate for sanitary protection in the Ware River watershed above the intake works at Coldbrook.

PROGRESS OF REAL ESTATE PURCHASES FOR WARE RIVER WATERSHED PROTECTION

	Title Vested in Commonwealth (Acres)
Total for year ending Nov. 30, 1935	663
Total to Nov. 30, 1934	5,532
Total to Nov. 30, 1935	6,195

Options outstanding Nov. 30, 1935, include 659 acres.

The only taking during the year was of the waters of Beaver Brook above the dike of Quabbin Reservoir, as shown in the appended table.

Diversion, Land and Business Damage Cases.—Data were prepared for the use of the attorneys in water diversion, land and business damage cases before the courts. Conferences were held and data collected jointly with representatives of manufacturers who have filed claims for diversion damages.

Contracts and Specifications.—Plans and specifications were completed for Contract 38, for constructing a core wall to sound rock at the site of the main dam of Quabbin Reservoir in the towns of Belchertown, Enfield and Ware. The contract was executed May 15.

Contract 48, an agreement with the State Department of Public Health, as to compensation for the right to discharge the sewage of the Rutland State Sanatorium into the Rutland-Holden sewer constructed under Contract 39, became effective when the sewer connection was completed November 7, 1934.

Plans and specifications were prepared for Contract 49, for excavating diversion channels in the towns of Dana, Hardwick and Greenwich, one completing the connection from Quabbin Lake on the East Branch of the Swift River to the lower intake of Quabbin Aqueduct at Shaft 12, one completing the outlet channel from Shaft 11A, and one across the divide between the East and Middle branches. The contract was executed October 2.

Contract 50, for constructing the embankment of the dike of Quabbin Reservoir in the towns of Enfield and Ware, was executed December 5.

Working drawings for Contracts 20, 36, 38 and 50 were prepared and issued.

Plans and specifications were completed for constructing the superstructure of the head house at Shaft 9 of Quabbin Aqueduct and the service building and the superstructure of the head house at Shaft 12 in the towns of Barre and Greenwich.

Work was in progress on the preparation of plans and specifications for constructing a baffle across the East Branch of the Swift River at the outlet of Walker's Mill Pond in the Town of Greenwich.

Inspection and Tests.—E. L. Conwell and Company continued the testing of cement until the latter part of March, after which time the testing was done by The Haller Testing Laboratories, Inc., of Plainfield, N. J. The Worcester Polytechnic Laboratory continued the testing of steel reinforcement bars and concrete cylinders. Steel reinforcement bars furnished for the main dam core wall under Contract 38 were tested and inspected by William R. Conard of Burlington, N. J. The inspection of miscellaneous iron furnished under Contract 20 was made by the engineering force.

Hydrographic Data.—The gaging station on the Ware River at Coldbrook was continued in cooperation with the United States Geological Survey.

The gaging station on the Chicopee River at the United Electric Light Company plant at Bircham Bend was continued in cooperation with that company and the United States Geological Survey.

The gaging station on the Swift River at Bondsville was continued in cooperation with the Otis Company.

The gaging station on the Swift River above the intake to the stream control tunnel at the main dam site was continued.

Cooperation with the United States Geological Survey in the operation and maintenance of the gaging station on the Connecticut River at Thompsonville, Connecticut, was continued.

In connection with the examination of the waters of the Ware, Swift and Chicopee rivers, observations of flow were continued from time to time and additional temporary gaging stations established as required and data for the use of consultants and experts were prepared.

Ware River Diversion

Ware River water was diverted into Wachusett Reservoir January 24, 25 and 31, February 16 to 19 inclusive, 21, 26 and 27, and March 4 and 5. No water was diverted between May 31 and December 1. At other times, the daily flow in the river was frequently sufficient to permit diversion, but except as above stated no diversion was made because of the present inadequacy of storage capacity in the reservoirs of the District. The quantity of water diverted during the year was 127,900,000 gallons. The steel bulkhead and gates, about 2,200 feet west of Shaft 8, prevent any flow of the Ware River westerly during diversion.. This bulkhead will be removed upon the completion of Quabbin Reservoir.

Sewage Diversion from Ware River Watershed

The Rutland-Holden sewer continued in operation. The fiscal year of the City of Worcester has been changed from the 12 months ending November 30 to agree with the calendar year, so that the current fiscal year includes 13 months ending December 31, 1935. During this period of 13 months, 31,028,200 gallons of sewage were received from the U. S. Veterans Hospital and 52,235,600 gallons discharged into the sewerage system of the City of Worcester.

Design of Structures

Shaft 1. Wachusett Outlet.—Studies were resumed of the requirements for the installation of gates to control the discharge from Quabbin Aqueduct into Wachusett Reservoir.

Power Development at Shaft 1.—Studies were resumed of the development of hydroelectric power and of the size and characteristics of the unit to generate power from the water discharged from Quabbin Aqueduct into Wachusett Reservoir.

Shaft 9.—Designs were continued for the superstructure of the head house at the top of Shaft 9 and for the requirements of an electric hoist to handle men and equipment in and out of the aqueduct at this point.

East Branch Baffle.—Studies were continued and designs made for a baffle across the East Branch of the Swift River near the outlet of Walker's Mill Pond. These designs include a concrete conduit through the base of the earth fill to carry the flow of the East Branch in its normal channel as long as desired. After this conduit is closed the entire flow of the East Branch will be diverted northerly so that the flow from the Ware discharged at Shaft 11A and from the East Branch will have the important benefit of longer storage in the main body of Quabbin Reservoir.

Shaft 11A.—Designs were made for one-way shutters to be installed at the top of Shaft 11A, to permit the discharge into the reservoir of water diverted from the Ware River and to prevent the drawing of water from the reservoir into the tunnel.

Shaft 12. Swift River Intake.—Studies were continued and designs made for the head house and the service building at the intake. Designs were continued of stop shutters required for unwatering the tunnel and of one-way shutters to permit the drawing of water from the reservoir into the tunnel and to prevent discharge into the reservoir of water diverted from the Ware River. Studies and designs were made of a water supply for the proposed buildings at Shaft 12, including a 15,000 gallon underground concrete tank 16 feet in diameter and 10 feet deep, about 45 feet above the floor of the service building. This tank is fed from a spring about 40 feet higher than the tank. Studies were made of the requirements for power to operate the shaft hoist and to furnish lights.

Shallow Flowage.—Studies were continued of the possibility of eliminating certain areas of fluctuating shallow flowage in the margins of Quabbin Reservoir by the construction of low dams to maintain the water level in such areas, when the main reservoir is drawn down.

Pumping Ground Water.—Studies were continued of the permeability of foundation materials at both the dike site and the main dam site, particularly the latter. Pumpage was continued at the rate of about 5,000 gallons per minute at the beginning of the year but this figure was gradually reduced during December and January to about 3,500. The ground water surface was lowered a maximum of about 85 feet below the original water level in the river to a point about 30 feet above the bottom of the rock gorge. This proved to be the practicable limit at the site and corresponded to a pumping rate of slightly less than 3,500 gallons per minute. This rate was maintained almost constantly during the remainder of the year and held the ground water near the condition existing at the end of January. The average permeability of materials below the ground water surface was estimated to be about 35 million gallons per acre per day under unit slope at 50° F. This corresponds to an average permeability of about 28 million gallons found at the dike site.

Caisson Core Walls.—Miscellaneous studies were continued in connection with the sinking of caissons for the core walls at the main dam and dike. The frictional resistance to sinking encountered at these sites was estimated to vary to a maximum of 500 pounds per square foot of vertical face below the surface from which the caisson is sunk. The caissons are designed with a slight taper of 1-32 of an inch in 1 foot on each of the two 45-foot sides, the two 9-foot ends being without any taper.

Main Dam and Dike Embankments.—Studies were continued and designs made for the embankment of the main dam. Studies were continued of methods of utilizing existing materials in the construction of the embankment. Studies were continued of observation wells to enable the future inspection, at all levels, of the interior of the impervious core of the hydraulic fill embankments. Three such wells are planned, two at the main dam and one at the dike, founded on the top of the caisson core wall and each being an extension of one of the wells in the core wall. At the bottom of each well, at an elevation near the original valley floor, piezometer connections will make it possible to observe the water pressure or head acting on both upstream and downstream sides of the core wall. The wells will be steel cylinders, 36 inches in diameter with frequent ports which can be opened for observing and taking samples of the core material to determine its degree and rate of compaction.

Office Buildings and Boathouse.—Studies were continued of the locations and requirements of permanent office and maintenance buildings including boathouse and hangar to take care of future reservoir inspection service under the condition of fluctuating reservoir level.

Main Dam Spillway.—Studies and designs were continued for the spillway and discharge channel east of the main dam site.

Power Development at Main Dam.—Studies were continued of the requirements of hydroelectric power development at the outlet works downstream from the stream control tunnel at the main dam.

Roads.—Studies were continued of substitute highways around Quabbin Reservoir and of locations for access roads to the main dam.

Aerial Map.—An aerial mosaic map of the site of Quabbin Reservoir was made, scale 1 inch = 1,100 feet.

Quinapoxet River Diversion.—Studies were continued relative to diverting into the aqueduct at Shaft 2 the waters of the Quinapoxet River for storage in Quabbin Reservoir.

Photographic Records.—The taking of moving pictures from time to time to illustrate the progress of the work was continued.

Tunnel Inspection.—The final inspection of the Coldbrook-Swift tunnel was made August 9 upon the practical completion of the construction work and studies were made of the best type of floating equipment for use in future inspections. A party of seven entered the lower intake at Shaft 12 with two canoes which were lowered through the shaft. The party then inspected the entire length of the tunnel section, passed through the doors of the steel bulkhead and inspected the Wachusett-Coldbrook section as far as Shaft 8 beneath the Ware River intake works and returned through the bulkhead leaving by way of Shaft 9. It was demonstrated that floating equipment for tunnel inspection should be of the lightest possible construction. The two canoes which were used proved very satisfactory. Such equipment must be light in order to have a minimum draft and be moved along easily when the party is walking, as traveling in the canoes was found to have no advantage over walking except where the water was deeper than about 0.8 foot over the tunnel invert. It was not practicable to travel in the canoes for more than 3½ miles of the total 13¾ miles. The tunnel was clean and in excellent condition.

Diversion of Industrial Wastes.—Studies were made of methods of diversion of objectionable wastes into the Rutland-Holden sewer constructed under Contract 39.

Quabbin Aqueduct Division

The Dam and Aqueduct Division until November 4, and thereafter the Quabbin Aqueduct Division, continued in charge of all work in connection with improvements on the Ware River watershed, of the construction and maintenance of the Rutland-Holden sewer, of the maintenance and operation of the Ware River intake works at Coldbrook and the Wachusett outlet works at West Boylston, and of miscellaneous surveys and studies in the Quabbin Reservoir area. The construction work at the main dam site is included in the following description of the work of the Quabbin Aqueduct Division.

Office Work

Semi-monthly estimates for Contract 38, one estimate for Contract 49 and the final estimate for Contract 39 were prepared. Additional real estate plans were prepared of miscellaneous property in the Ware River watershed, final tracings being made of about 800 acres. Record plans were prepared of the Rutland-Holden sewer constructed under Contract 39. Final plans were made of the area along the tunnel line and along the watershed divide. This divide is shown on a set of index plans, scale 1 inch = 1,000 feet. Topographic maps were made of the area in the vicinity of the Jefferson Mfg. Company, Holden. Daily rainfall and temperature records and continuous records of the flow of the Ware River were kept at the intake building and daily rainfall records were kept at West Rutland. Studies were continued of materials, comparative costs and methods of construction of the main dam and dike.

Field Work

Topographic surveys were made in the vicinity of the Jefferson Mfg. Company, Holden, covering about 120 acres, at the site of possible borrow areas northeast of the main dam covering about 550 acres, and along the line of the Ware River watershed divide. The survey of this divide was completed, the total length being 75.3 miles including 18.7 miles adjacent to the Wachusett watershed, which had been previously surveyed by the Metropolitan District Commission. A sanitary survey of the operation of the Jefferson Mfg. Company was made during the week ending August 3. Lines and grades were given for for construction under Contracts 38 and 49. Additional stone bounds were set defining property acquired by the Commission in the Ware River drainage area. The triangulation system in the Ware River drainage area was extended and tied to other systems of the United States Coast and Geodetic Survey and of the State Commission on Waterways and Public Lands.

Monthly inspections and reports were made of conditions found at all shaft heads along the Quabbin Aqueduct.

The State Department of Public Health continued its cooperation with this division in the analysis of samples of water and sewage effluents. The chlorinator station on Mill Brook below the Central New England Sanatorium was maintained.

In connection with studies of the method of construction of the main dam and dike, surveys of topsoil and of glacial overburden were continued in the vicinity of both structures.

Operation of Ware River Intake Works

Operation of the Ware River intake works was continued. Water was diverted into the tunnel from time to time in January, February and March. The tunnel was entered for inspection through Shaft 8 on April 8, July 30 and November 5. The one-way drain valves through the bulkhead were opened July 30. The steel bulkhead 2,200 feet west of Shaft 8 continued in excellent condition. The concrete tunnel lining east of the bulkhead and adjacent to the construction operations under Contract 20 was found to be clean and in excellent condition.

Operation of Rutland-Holden Sewer

Operation of the Rutland-Holden sewer was continued. The meter stations at the Rutland State Sanatorium, at the U. S. Veterans Hospital in Rutland, and at the Holden-Worcester boundary line were inspected regularly and wiers and piezometer connections cleaned and records of flow maintained.

Miscellaneous Construction

Between December 15 and May 27, the interval between completion of work on exploratory caissons numbered 7 and 9 at the main dam under Contract 36 and the beginning of work of sinking the remaining caissons to complete the core wall under Contract 38, pumping operations were continued by the Commission's force. The pumping plant was as follows: in caisson 7, eight pumps, each with a capacity of 800 gallons per minute; in caisson 9, three pumps of 800 and one of 300 gallons per minute capacity; and in caisson 20, one of 300 gallons per minute capacity, all these ratings being at 90-foot head. The rate of pumpage decreased from 4,480 gallons per minute on December 15 to 3,490 gallons per minute on May 15.

A small labor force was employed throughout the year on miscellaneous work in caring for the grounds at the Ware River intake, Wachusett outlet and Shaft 4 head house, setting stone bounds, filling cellar holes, grading and cleaning up at the sites of buildings removed from the Ware River watershed and other miscellaneous work. The average number of men so employed on force account was 8, the maximum 20 and the minimum 3.

Progress of Contracts

Contract 35.—Contract 35, with the New England Power Company for the purchase of electricity for experimental work at the main dam site, was continued to completion. Under this contract power was purchased for use in experimental pumping from the exploratory caissons.

During the year a total of 555,000 kilowatt hours was furnished, making the total during the life of the contract 1,159,535 kilowatt hours. The cost of electricity furnished during the year was $8,382.98, making the total cost from June 2, 1932, to June 1, 1935, $19,367.18.

Contract 38.—Bids were opened May 7, for constructing a core wall to sound rock at the site of the main dam of Quabbin Reservoir in the towns of Belchertown, Enfield and Ware. Nine bids were received, ranging from $1,330,765.00 to $1,818,200.00. The contract was executed May 15, with C. J. Maney Company, Inc., Boston, and B. Perini & Sons, Inc., Framingham, the low bidders, who assigned the contract to, and are now operating under the name of The Two Companies, Inc.

The work consists mainly of excavating an open trench across the valley about 2,700 feet long and about 30 feet deep, sinking a row of 37 concrete caissons (three other caissons were previously sunk for explorations under earlier contracts), from the bottom of this trench to sound rock, refilling both caissons and trench with impervious materials, and constructing consolidated pervious embankments both upstream and downstream to form the toes of the future main dam embankments in preparation for the construction of the latter by hydraulic sluicing.

Excavating of the open trench was started May 17. The removal of the track of the Athol Branch of the Boston and Albany Railroad crossing the site was completed July 31, and the excavation of open trench practically completed, August 20. The highway crossing the site of the dam was discontinued as a public way, August 13. The open-cut trench was extended up the hillsides to the elevation of the top of the dam. Stripping of the site was practically completed. Suitable impervious materials from these operations, together with impervious soil from borrow areas north of the site, were stored for later use in refilling the open trench. Silt and other unsuitable materials from the stripping operations were wasted in the abandoned river bed both upstream and downstream from the site and in other spoil areas. Suitable pervious materials from the excavations were placed in the required embankments. The upstream and downstream cofferdams, forming the toes of the future embankment, were built and fills between these cofferdams and the central core wall were graded on a slope of not over 5 per cent toward the central open trench, in preparation of the work of hydraulic sluicing of the main embankment under a future contract.

Materials for the pervious fills were generally dumped from trucks, spread in layers with bulldozers, and then rolled with either a 12-ton, 3-wheel roller or with a sheep's-foot roller. The 3-wheel roller was equipped with cleats on the rear wheels. All layers were thoroughly sprinkled before and during rolling. Materials containing boulders, where rolling was impractical, were consolidated in water by local ponding.

The cofferdams were completed November 8, the upstream cofferdam to elevation 430 and the downstream cofferdam to elevation 420. The original river bed was about elevation 380. All the consolidated pervious embankments were practically completed during the year. Rock from the open-cut ledge excavation and spoil from the previously excavated stream control tunnel together with some crushed stone from the concrete aggregate plant was placed in required stone fills in the downstream toe, in drains through the downstream cofferdam and in riprap on the face of the upstream cofferdam. These rock fills were nearly completed during the year.

On May 27 the contractor took over and continued the operation of pumps in the three exploratory caissons sunk under previous contracts. From this date until the end of the year the total quantity pumped in operations for lowering the ground water level was 890 million gallons, an average of 3,296 gallons per minute. The minimum daily rate was 1,807 gallons per minute on October 26, and the maximum 4,065 gallons per minute on August 4. In addition to pumping from the three exploratory caissons which were especially equipped for this work, the contractor pumped from time to time from five other caissons. In two of these, strainers were installed in the underpinning providing equipment similar to that in the exploratory caissons. In two others, diaphrams were installed in the bottom of the caisson wells, through which pumping was done directly from the working chamber. In the other caisson pumping was done from an open sump. The contractor had in all 12 pumps in service with a total capacity of 7,460 gallons per minute. Individual pumps varied in capacity from 200 to 800 gallons per minute, the largest having a capacity of 600 gallons per minute under 230-foot head driven by 50-horsepower motor. The pumps were centrifugal, electrically driven units of the mine type. The pumping operations lowered the ground water in the deepest portion of the rock gorge to a point about 85 feet below the original water level in the river.

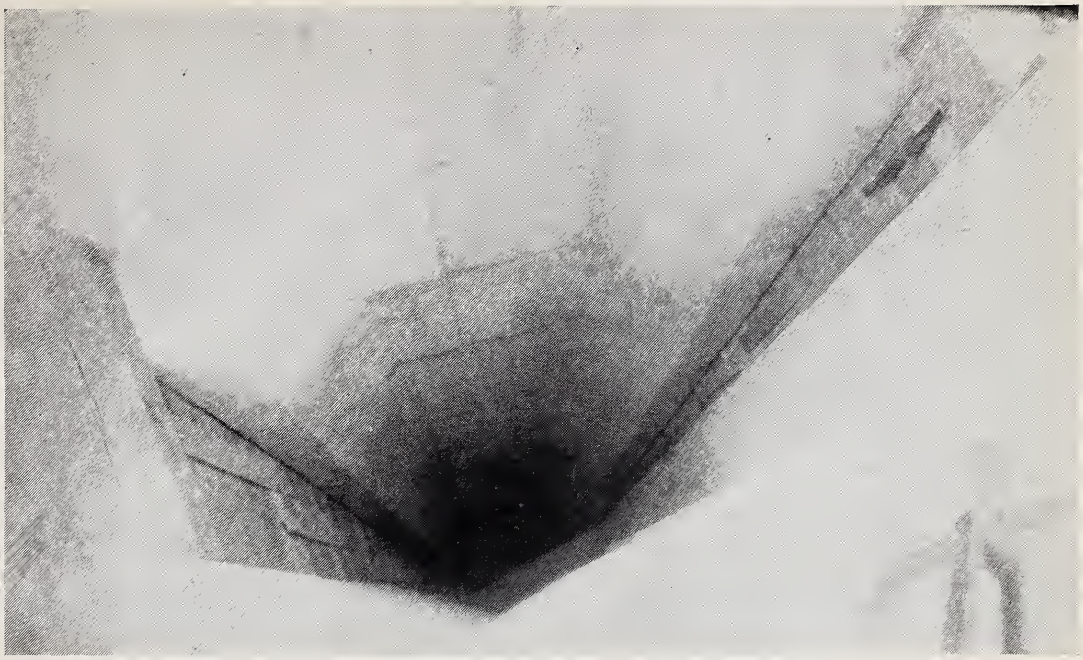
The river is diverted from its original bed into a channel paved for watertightness at a point 800 feet upstream from the core wall. The point of discharge from the downstream end of the stream control tunnel into pervious material is about 1,500 feet downstream from the core wall. The ground water has been lowered as follows:

Location	By exploratory caissons, to May 27	Additional under this contract to November 30	Total
At core wall	85 ft.	0 ft.	85 ft.
115 ft. upstream	70 ft.	2 ft.	72 ft.
500 ft. upstream	41 ft.	7 ft.	48 ft.
820 ft. upstream	23 ft.	7 ft.	30 ft.
1,700 ft. upstream	5 ft.	5 ft.	10 ft.
105 ft. downstream	71 ft.	6 ft.	77 ft.
800 ft. downstream	28 ft.	10 ft.	38 ft.
2,000 ft. downstream	4 ft.	10 ft.	14 ft.

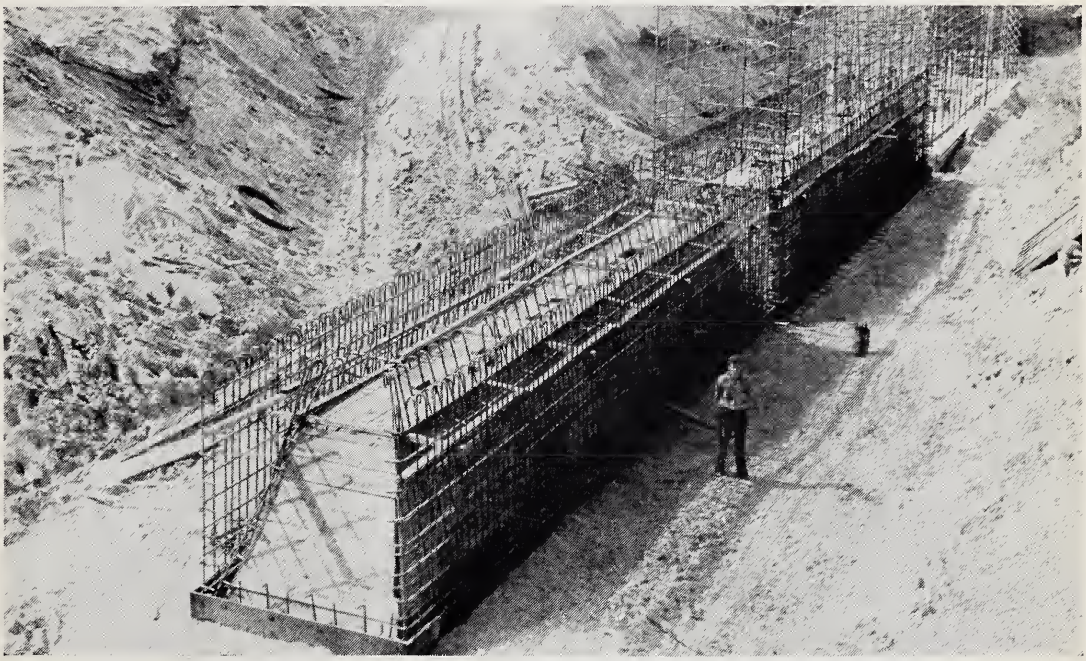
The contractor was paid for caisson excavation at bid prices for the yardage between fixed elevations independent of the air pressure required, and is paid for pumping not at a bid price but at a fixed price of 10 cents per million foot-gallons.

The caisson construction was started June 18, when the shoes of caissons 11 and 12 were set. A screening, crushing, washing and batching plant for concrete aggregates was completed June 17 at a sand and gravel borrow pit along the highway about 700 feet north of the site. Aggregates were hauled to a portable mixing plant which was set up on the edge of the open-cut trench and concrete was delivered from this plant by means of a caterpillar-mounted belt conveyor spanning the trench to the core wall. This equipment had a boom with an effective length of 65 feet which could be raised to a considerable height. A small hopper and jointed pipe hung from the end of this boom which could be raised and lowered to accommodate the surface of concrete in the forms. The first concrete was placed June 22. Caisson 12 was the first to strike water, reaching it at elevation 332 July 29. Work on the remaining caissons progressed very rapidly. The last shoe, number 1, was placed October 7. The first caisson sealed to rock was number 5 on August 23. The methods employed were in general similar to those described in previous reports in the case of the caisson core wall for the dike constructred under Contract 36. At the start of the work three air compressors with a total capacity of 2,550 cubic feet of free air per minute were used. Later a compressor with a capacity of about 600 cubic feet per minute was added. This equipment was sufficient for working three caissons simultaneously. Later, an additional compressor having a capacity of about 1,600 cubic feet per minute was installed and four caissons were worked simultaneously. Additional capacity of 400 cubic feet per minute and pressures up to 100 pounds per square inch were used to drill grout holes. High-pressure water jets were used to dislodge boulders. Concrete was generally cast in 16-foot lifts against steel forms, four sets of which were used. Caissons were sunk in dry material by the use of head frames mounted on the caisson. An electric two-drum hoist mounted on one end of a caisson handled buckets in each of the two muck shafts. The buckets were dumped over the sides of the caisson and the spoil loaded into trucks by a gasoline-driven shovel operated in the bottom of the cut. During air sinking the hoist was set up on the edge of the open cut opposite the caisson. Four sets of air locks were used. A temperature of about 70° was maintained in the working chambers.

A large percentage of the air work consisted of excavating to sound ledge after the actual sinking of the caisson was discontinued. In this operation underpinning walls about 9 inches thick were built as soon as the excavation for approximately a 3-foot depth was completed. Concrete for these walls was mixed in the working chamber by hand with aggregates lowered in the muck buckets. The depth of underpinning walls varied from 1 foot to a maximum of about 15 feet. The excavation of end joints between caissons was done generally by crews of two men each, the sides of the excavation being supported by wooden lagging spanning the extreme outer corners of adjacent caissons. A single crane handled small muck buckets for two keyways. Several of the keyways were excavated by pulling the material into the working chamber of an adjacent caisson. In keyways which required excavation under air the keyway was excavated in the open to the ground water level and a cylindrical shaft form some 3 feet in diameter installed. The concrete was then placed around this form by using the jointed pipe attached to the concrete conveyor boom, and vibrated by lowering the vibrator on a rope. An air lock was then installed the same as for the caisson itself.



Contract 38. — Looking Down Excavated Keyway Between Caissons Numbered 2 and 3.



Contract 38. — Main Dam Caisson Core Wall, Cutting Edges and Working Chamber Forms and Reinforcement, Caissons Numbered 39 and 40.

In extending the tops of caissons to the required uniform height 25 feet above the bottom of the open-cut trench the steel forms were dismantled to obtain sections of approximately the correct height. When only one or two feet of additional height were required, wooden forms were used.

Grouting from the working chambers at the bottoms of caissons was started October 23. At the end of the year preliminary grouting in 13 caissons and final test grouting in 8 caissons was completed, and 4 working chambers were sealed with concrete. In the grouting operations, 6 holes were drilled from the bottom of each caisson into the concrete seal and 20 feet into the rock. These holes were grouted using pressures up to 50 pounds per square inch. A week or ten days after grouting was completed in any area, three test holes were drilled through the seal in each caisson. Such holes were generally tight and in only a few cases did they take any grout.

At the end of the year all the caissons had been sunk except numbers 12, 14 and 19, which were nearly sunk, caissons 11 and 15 were being sealed and all others had been completely sealed. The end joints between caissons were about 70 per cent excavated and about 50 per cent completely sealed with concrete. The average rate of sinking in the open was 9.77 feet in 24 hours under atmospheric pressure, and under air 3.63 feet. The ground water was lowered to such an extent that although the maximum depth of sinking below the original ground water level was 125 feet, a pressure in excess of 18 pounds per square inch was exceeded in only five caissons, and in excess of 26 pounds in only two caissons. The maximum pressure required was 29 pounds in caisson 10 where it was necessary to work below the level of the pumping intakes in exploratory caisson number 9, thus requiring the shutting down of these pumps. Nine of the 37 caissons under this contract did not require the use of compressed air. There were 295 caisson days of pressure below 18 pounds, 36 between 18 and 26 pounds and 6 between 26 and 29 pounds.

The value of work included in contract estimates to November 15, the date of the latest estimate, was $1,021,829.00, of which 90 per cent was approved for payment. The contractor's force averaged 332 men, the maximum being 508 for the week ending August 31.

The total electric energy used by the contractor was 1,650,955 kilowatt hours.

The principal items of plant were as follows:

6 Gasoline shovels, including two with convertible booms
3 Traveling cranes
3 Bulldozers
2 Power scrapers with Diesel tractors
2 12-ton gas rollers
1 Sheep's-foot roller
1 Crushing, screening and washing plant
1 Aggremeter
1 1-cu. yd. dual drum paving mixer
1 Caterpillar-mounted concrete conveyor
4 Low pressure air compressors, total capacity 4,150 cu. ft. per min.
2 High pressure air compressors, total capacity 1,000 cu. ft. per min.
64 Ft. height of steel caisson forms
4 Man locks
4 Muck locks
1 Hospital lock
12 Pumps, as previously described
Trucks, hoists, portable compressors, drills, etc.

The total work done and materials furnished to date under the principal items of Contract 38 are as follows:

Earth excavation in open cut	224,600 cu. yds.
Rock excavation as boulders in open cut	320 " "
Rock excavation as ledge in open cut	10,800 " "
Stripping	51,100 " "
Unconsolidated embankment	8,240 " "
Consolidated pervious embankment	167,900 " "
Rolled impervious embankment in core	14,070 " "
Rolled impervious embankment not in core	18,350 " "
Stone Fills	37,750 " "
Pumping	87,600 mil. ft. gals.
Earth excavation for core wall bottom of open cut to elevation 300	31,410 cu. yds.
Earth excavation for core wall below elevation 300	2,910 " "
Rock excavation in caissons to elevation 300	2,300 " "
Rock excavation in caissons below elevation 300	350 " "
Concrete not placed under air pressure	42,150 " "
Concrete placed under air pressure	4,450 " "
Portland cement	69,310 bbls.

Contract 39.—Contract 39, for constructing a trunk sewer in the towns of Rutland and Holden, was continued to completion. There has been paid the Contractor in full settlement of all claims $238,708.67.

Contract 49.—Bids were opened September 10, for excavating diversion channels at the site of Quabbin Reservoir in the towns of Dana, Hardwick and Greenwich. Twelve bids were received, ranging from $79,050.00 to $207,155.00. The contract was executed October 2, with Cenedella & Company, Milford, Mass., the low bidder. Clearing the site of the diversion channel and spoil area between the Middle and East branches was started October 21, and the spoil area at the lower intake channel at Shaft 12, October 26.

Excavation of the lower intake channel at Shaft 12 was started November 6, using a gasoline crane with 70-foot boom and 2⅓-cubic yard drag bucket. Muck excavated from this channel was trucked to a spoil area north of the channel and suitable material from below the muck was spread over the area adjacent to the channel. This channel was completed November 16, except for some trimming of slopes.

The excavation of the channel between the East and Middle branches of the Swift River was continued, using a 90-horsepower caterpillar scraper which started work November 4. The crane previously used at the lower intake channel at Shaft 12 started on this work November 16.

The work of clearing the site of the outlet channel at Shaft 11A was started November 8.

The value of work included in contract estimates to November 12, the date of the latest estimate, was $7,300.00, of which 90 per cent was approved for payment.

The total yardage excavated to date is 10,000 cubic yards in the lower intake channel at Shaft 12 and 75,600 cubic yards in the diversion channel between the East and Middle branches of the Swift River.

COLDBROOK-SWIFT TUNNEL DIVISION

The Coldbrook-Swift Tunnel Division, until its discontinuance October 31, continued in charge of the construction of the Coldbrook-Swift tunnel section of Quabbin Aqueduct and, until September 16, of river surveys along the Ware, Swift and Chicopee rivers.

Office Work

Tunnel cross sections were plotted and excavation and masonry volumes computed therefrom. Semi-monthly estimates and the final estimate were prepared for Contract 20. Plans and topographic maps were made of the areas at and near Shafts 11A and 12, for an access road to Shaft 12, of the Quabbin Reservoir watershed divide, and of miscellaneous areas along the Ware River. The preparation of geologic field notes and specimens for a permanent geologic record was continued. These specimens were permanently stored in the Ware River intake building.

Field Work

Lines and grades were given for construction on Contract 20. Surveys for record were made of the stop log and screen grooves in the Swift River intake at Shaft 12. About 525 acres of topography were taken along the Ware River and tributaries below the intake and in the vicinity of Shaft 12. The taking of photographs of the construction work and of rock formations of geological interest was continued. Excavation for a water supply tank for buildings at Shaft 12 was begun July 25 with a small labor force. The tank was completed September 14. The spring supplying the tank was deepened, walled up with stone and covered September 27. The distributing pipe from the tank to Shaft 12 and the temporary branch office of the division was completed October 8. Laying of the supply pipe from the spring to the tank was in progress October 31, when the division was discontinued. The labor force employed in this work reached a maximum of 14 for one week.

The collection of data pertinent to the determination of the water power available and developed at various plants on the Ware, Swift and Chicopee rivers and to the determination of flows at various points under varying conditions, and the investigation of the quality of the water in these rivers was continued until September 16, when the personnel engaged therein was transferred to the Quabbin Reservoir Division.

Progress of Contracts

Contract 20.—Contract 20, for the construction of the Coldbrook-Swift tunnel section of Quabbin Aqueduct, through the towns of Barre, Hardwick and Greenwich, was continued to completion.

During the year the work consisted principally of completing the substructure of the future head house at the top of Shaft 9; installing the ladder and platforms for access to the bottom of the shaft and constructing a chamber at the bottom of the shaft to permit the future installation, in any emergency, of a tunnel unwatering pump at this point to supplement the pump at the bottom of Shaft 1; sinking and lining Shaft 11A and constructing an outlet at the top of this shaft for the discharge into Quabbin Reservoir of water diverted from the Ware River; completing the lining of Shaft 12 and the substructure of the intake works at the top of this shaft; grouting the timbered sections of the tunnel and the 200-foot length just east of the intake at Shaft 12 which was constructed as a pressure tunnel with circular cross section; and cleaning up.

Tunnel lining was completed at Shaft 10 about the end of February and the use of bulk cement was then discontinued.

Cleaning the tunnel between Shafts 12 and 9 was done by two parties of 7 to 9 men each. The work progressed downstream to take advantage of water flowing on the invert. Small portable wooden dams about 12 inches high were placed across the invert 200 or 300 feet apart, the section cleaned with brooms and then flushed by removing the dams. Heavy material was shoveled into buckets and transported by an automobile truck driven by electric storage batteries. The contractor continued to employ local physicians who made weekly reports on the health of his employees and on the sanitary conditions of each of his camps.

The value of work included in contract estimates during the year was $205,339.44, the final estimate dated October 1, being for $4,809,852.83.

Shaft 9.—The work of concreting the emergency pump chamber at the bottom of this shaft was completed January 5. The contractor then installed pumps in this shaft to maintain the entire tunnel in a dry condition. The work of placing the steel ladder and platforms in the shaft was begun about April 15. The extension at the top of the shaft of the 20-inch emergency pump discharge line embedded in the shaft lining was completed May 6. The contractor thereafter used this pipe, with a temporary 50-foot extension, as a discharge line for his tunnel pumps. To complete the concrete work at the top of the shaft a temporary concreting plant was set up north of the shaft. Excavation for the spillway was started May 13, the wing walls and head walls of the culvert being carried down to sound rock. Masonry work for the spillway outlet was completed July 13, and paving at the outlet was completed August 20. All equipment was removed from the shaft and the headframe taken down June 18. Pumping in the tunnel was discontinued August 8. Work on the access road was started about July 5 and completed about August 28. Cleaning up débris from the camp sites, removing plant and equipment, grading borrow pits, etc., was completed September 26. All work at the shaft was practically completed September 14. The contractor's force averaged 10 men, the maximum being 35 during the week ending August 3. The contractor's camp at this plant was unoccupied except by a watchman.

Shaft 10.—The tunnel lining, consisting of 521 feet easterly and 499 westerly, was continued to completion February 20. The precast beams and slabs for closing the top of the shaft were cast about April 10. Grouting of vent holes in the tunnel arch at this shaft was started April 15 and completed May 2. All equipment was removed from the shaft and the site, and the headframe taken down July 23. The concrete top of the shaft was completed August 3, and grading over the shaft August 13. All work at this shaft was practically completed September 28. On December 3, 1934, the dry house and contractor's office building were destroyed by fire. These buildings were not replaced but alterations were made in other buildings to give the necessary accommodations.

The contractor's force averaged 16 men, the maximum being 60 during the week ending September 8. The average number of persons occupying the camp was 12 until January 12, after which the camp was unoccupied except by a watchman.

Shaft 11.—Grouting of the timbered sections and vent holes in the tunnel roof at this shaft was started May 2 and completed about May 20. Concreting the shaft connection at the bottom of the shaft was completed June 11. The headframe was removed July 14. The concrete top of the shaft was completed and the precast beams and slabs placed August 1. Equipment was removed and all grading and cleaning up at the top of the shaft were completed August 8. All work at this shaft was practically completed August 17. The contractor's force averaged 6 men, the maximum being 27 during the week ending July 13. The contractor's plant at this camp was unoccupied except by a watchman.

Shaft 11A and Ware River Outlet.—The contractor started December 3 to drive an 8-inch casing to ledge and to drill a 6-inch hole to the tunnel on the center line of this shaft, in order to drain the ground water interfering with his excavation into the tunnel. This hole reached the tunnel January 6. Excavation of the outlet channel was resumed February 25 and completed about March 25. About March 10, the contractor set up a derrick and compressed air hoist and started shaft excavation March 25. After some difficulty with fine running sand, ledge was reached April 6. The excavation was continued through about 80 feet of rock, breaking through into the tunnel April 26. A concreting plant was set up at the edge of the excavation. Cement in bags was hauled from Greenwich Village, sand from a borrow pit on the highway nearby, and stone from the aggregate pile at Shaft 10. Concrete lining of the shaft in rock was poured from May 6 to May 29. The extension at the top of the shaft containing the outlet passages and culvert to the reservoir was completed July 11. Stone masonry in the culvert wing walls and head wall was completed July 5. Back filling, paving and riprap were completed August 5. All work at this shaft was practically completed August 17. The contractor's force averaged 12 men, the maximum being 26 during the weeks ending May 11 and 25. No provision was made for the housing of contractor's employees at this shaft, the camp being occupied by only a watchman.

The principal items of plant were as follows:

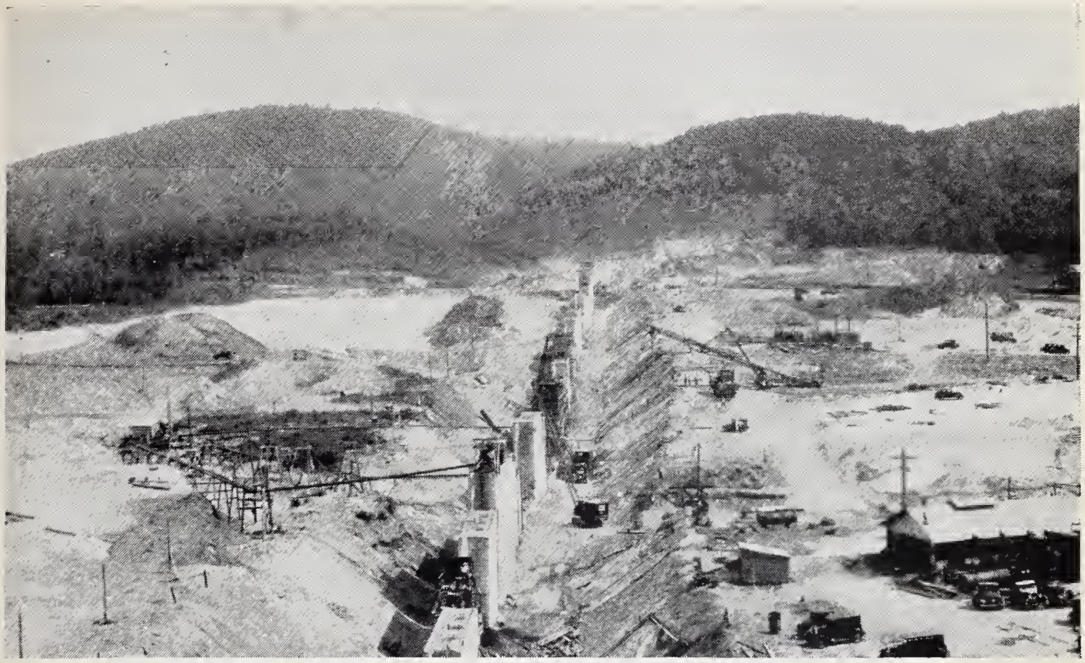
1 Derrick with 52-ft. boom
1 Compressed air hoist
2 Air compressors, each having a total capacity of 550 cu. ft. per min. and driven by 125 H.P. motor
1 1-cu. yd. concrete mixer
3 Pumps, the largest having a capacity of 1,700 gals. per min. under 50-ft. head with 15 H.P. moto

Shaft 12 and Swift River Intake.—Placing concrete in the shaft lining and head house substructure was continued at this shaft. Construction was carried on inside a steam-heated wooden shelter covering the entire working space at the top of the shaft to allow laying of stone masonry to continue in cold weather. This shelter and the derrick were raised to include the upper part of the structure between January 18 and February 2. Construction of stone masonry wing walls was commenced December 15, 1934. Stone and concrete work in the head house substructure was continued to completion May 4.

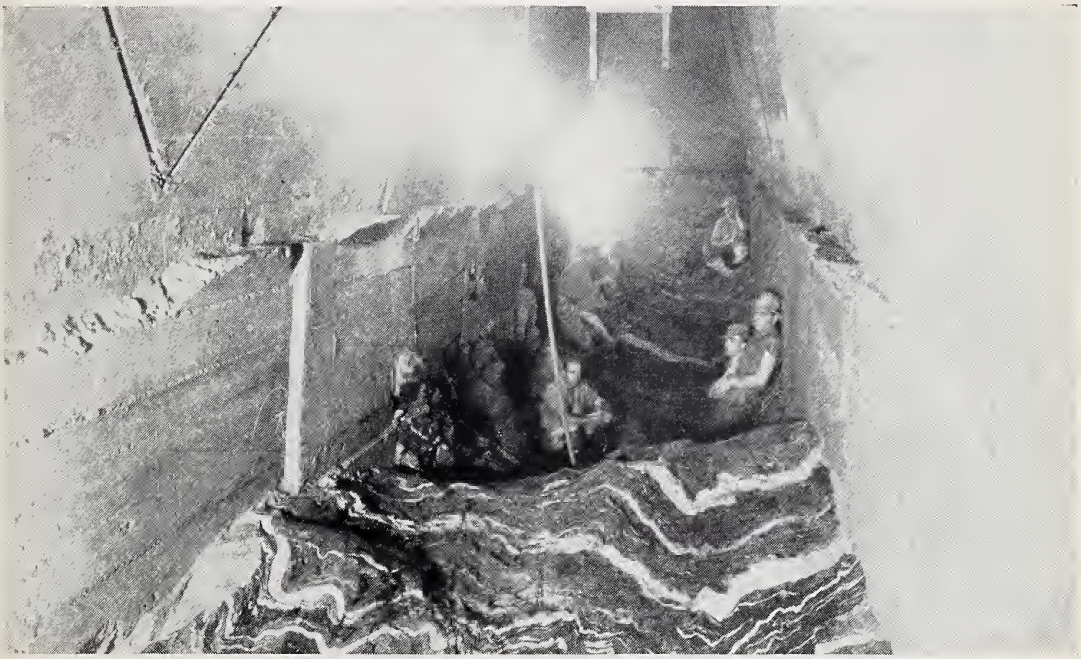
Grouting of the circular or pressure section of the tunnel just east of the shaft and grouting of the shaft itself was started April 13 and completed May 13. Excavation of the upper intake channel was started May 6. Material was deposited in the approach fill to the shaft and was consolidated with water to reduce the amount of future settlement. To complete this fill, additional material was obtained from a borrow pit below the flow line. The placing of crushed stone from the aggregate pile and riprap and paving from the upper intake channel excavation and from miscellaneous borrow areas was completed July 27. The paving adjacent to the substructure and wing walls was grouted. Practically all the work at this shaft was completed August 31. The contractor's force averaged 21 men, the maximum being 38 for the week ending March 9. The contractor's camp at this plant was unoccupied except by a watchman.

There was no material change in plant items during the year.

The total work done and materials furnished under the principal items of Contract 20 are as follows:



Contract 38. — General View of Caisson Core Wall Looking East Across Main Dam Site.



Contract 38. — Main Dam Caisson Core Wall, Underpinning to Sound Rock in Working Chamber of Caisson Number 5.

	Shaft 9	Shaft 10	Shaft 11	Shaft 11A	Shaft 12 and Intake
Earth excavation for shafts (cu. yds.)	85	319	225	339	*
Rock excavation in shafts and in tunnel within 50 feet of shafts (cu. yds.)	2,366	3,656	2,275	409	1,432
Excavation in tunnel, except within 50 feet of shafts (cu. yds.)	101,791	105,873	105,989	0	60,620
Shaft and tunnel drainage (lin. ft.)	16,964	16,788	15,918	110	8,905
Earth excavation in open cut (cu. yds.)	1,548	2,137	1,804	3,155	42,809
Rock excavaton in open cut (cu. yds.)	35	439	106	26	2,730
Forms for concrete lining in shafts (lin. ft.)	196	410	270	104	0
Forms for concrete lining in tunnel (lin. ft.)	13,652	16,738	15,348	0	9,090
Concrete masonry in shafts (cu. yds.)	744	1,141	810	327	0
Concrete masonry in tunnel (cu. yds.)	28,579	35,880	32,256	0	19,095
Concrete masonry not in shafts or tunnel (cu. yds.)	101	0	1	148	2,959
Permanent timbering in tunnel (M ft. B.M.)	37	231	55	0	29
Temporary timbering in tunnel (M ft. B.M.)	11	6	5	0	0
Portland cement (bbls.)**	47,100	59,600	53,200	760	35,330
Steel for reinforcing concrete (lbs.)	7,892	1,137	1,137	20,492	139,573
Gunite protective coating of tunnel rock (lin. ft.)	3,994	3,661	0	0	0
Refilling and embanking (cu. yds.)	2,697	5,040	569	2,459	16,456
Miscellaneous cast iron, wrought iron and steel (lbs.)	53,935	3,924	485	6,857	229,361
Riprap (cu. yds.)	—	—	—	252	2,568
Paving (cu. yds.)	95	—	—	13	561

* Included in item "Earth excavation in open cut."

** Cement proportioned to concrete masonry at each shaft.

Electric power for all contract requirements was purchased by the contractor. The total consumed at the different shafts during the year was as follows:

	K.W.H.
Shaft 9	441,600
Shaft 10	335,800
Shaft 11	392,600
Shaft 11A	76,500
Shaft 12	195,400
Total	1,441,900

The total electric power consumed on Contract 20 from beginning of work April 23, 1931 to the removal of the power line October 1, 1935 was 24,549,269 kilowatt hours, the total length of tunnel excavated being 54,831 linear feet and the total length of tunnel lined being 54,862 linear feet.

Quabbin Reservoir Division—Enfield Office

The Quabbin Reservoir Division continued in charge of the field work in the Swift River valley in connection with the proposed Quabbin Reservoir including topographic and real estate surveys, cemetery removals, and the soil testing and water analysis laboratories. On September 16 this division took charge of the investigations, surveys, etc. along the Ware, Swift and Chicopee rivers. This division also continued in charge of construction work at the dike site and of the construction of the Daniel Shays Highway, formerly referred to as the Belchertown-Pelham highway and its extensions.

Miscellaneous Office Work

Semi-monthly estimates for Contract 50, monthly estimates for Contract 23, and the final estimates for Contracts 23, 36, 41, 43 and 44 were prepared. Topographic maps were prepared and studies made of possible highway relocations northerly and easterly of Quabbin Reservoir. Record plans and tracings were prepared of the Ware-Belchertown highway constructed under Contract 21 and the Belchertown-Pelham highway constructed under Contract 41. Revised topographic plans of the main dam site and its vicinity were made. Photographs of the progress of construction carried on under the supervision of this and other divisions were taken. Meteorological records at Enfield were continued.

Miscellaneous Field Work

Lines and grades were given for construction on Contracts 23, 43, and 50. Daily readings of the ground water level and numerous test wells were continued during the pumping operations at the dike, and until December 15, 1934, at the main dam. Following the diversion of Beaver Brook above the dike April 12, the depth of water upstream from the dike gradually increased until at the end of the year it stood 6.75 feet above the original surface of Morton Pond, and within 10.25 feet of the point at which the flow will be diverted northerly into the Swift River.

Necessary data on topographic and other features were taken in connection with the studies for highway relocation.

Reservoir-General

Topography.—Topography in the vicinity of the flow line of the reservoir was completed. To date 30,320 acres or 47.4 square miles have been surveyed for the general topographic maps within and adjacent to the proposed reservoir, including the topographic location of the entire flow line. About 47.3 miles of the Swift River watershed divide was surveyed, making a total to date of 67.7 miles, 11.9 miles of which was surveyed by the Coldbrook-Swift Tunnel Division.

Real Estate.—Properties described in applications by owners for sale of real estate were located and when no surveys had been made sketches showing the approximate location were prepared. Comprehensive real estate surveys and analyses and descriptions of deeds were continued. Real estate surveys during the year cover 4,106 acres, making a total to date of 64,107 acres or 100.17 square miles. Of this total, 62,258 acres have been plotted on a scale of 1 inch = 200 feet. No additional final tracings were made.

Photography.—The photographing of buildings and cemetery lots within the area to be affected by the proposed reservoir was continued. During the year 73 photographs of buildings and 365 of miscellaneous views and of the progress of construction carried on under the supervision of this and other divisions were taken. Also, 99 photographs of property in the Ware River watershed were taken.

Cemetery Removals.—Interments in Quabbin Park Cemetery and the general removal of bodies from existing cemeteries in the reservoir area were continued. The removal of bodies, headstones and monuments has been done with labor engaged directly for this work. During the year work progressed as shown in the following table:

CEMETERY REMOVALS

		To Nov. 30, 1934†	Year Ending Nov. 30, 1935	Total
Burial lots in Quabbin Park Cemetery assigned in exchange		441	80	521
Burial lots in Quabbin Park Cemetery sold		15	5	20
Number of releases executed of rights in old lots in Quabbin Reservoir area	to Q. P. Cemetery	212	80	292
	to other cemeteries	136	22	158
Bodies removed from Quabbin Reservoir area	to Q. P. Cemetery	1,126	514	1,640
	to other cemeteries	786*	39	825*
Bodies removed from area outside Quabbin Reservoir to Quabbin Park Cemetery		2*	1	3*
Burials, not reinterments, in Q. P. Cemetery		54	17	71
Headstones moved	to Q. P. Cemetery	672	256	928
	to other cemeteries	362	22	384
Monuments moved	to Q. P. Cemetery	121	54	175
	to other cemeteries	131	7	138

† Quabbin Park Cemetery was not completed ready for use until August 25, 1932, prior to which time 632 bodies had been removed to other cemeteries.

* Includes one body originally moved outside and then back to Quabbin Park Cemetery.

The vault was maintained in readiness for use during the winter months. Work of developing Quabbin Park Cemetery was continued by grading and seeding miscellaneous areas outside the established lots and by miscellaneous clearing and grubbing where trees interfered with the setting of stone. Cemetery lots were graded and seeded as removals were completed and in the case of purchases were graded and seeded at once. The average force employed on cemetery development during the working operations was 13 men, the maximum being 16 during the week ending May 25.

Fire Protection.—The fire fighting equipment was continued in readiness for service at all times. Five assistants in the division office were reappointed as deputy forest wardens in each of the towns affected by the reservoir. The equipment and personnel responded during the year to calls for assistance at 16 forest fires which burned over a total area of about 1,178 acres. The large acreage involved was due to two large fires of incendiary origin set during a period of unusual fire hazard conditions. There also occurred a total of 23 fires in buildings, 8 of which were chimney fires resulting in little if any damage.

Lumbering.—The New England Box Company continued its cutting operations under agreements with the Commission for the purchase of standing timber. The lumber was stacked as cut and hauling away commenced July 17 and continued throughout the year. During the year about 4,790,500 ft. B.M. were cut, and about 4,247,000 ft. B.M. were hauled, the corresponding totals to date being about 9,210,500 ft. B. M. cut and 5,775,000 ft. B.M. hauled. In addition, miscellaneous standing timber at various places throughout the valley has been sold to other operators and cut under the general supervision of this division.

Reforestation.—The general program of reforestation was started during the spring with nursery stock obtained from the Clinton and Amherst nurseries of the Department of Conservation. Planting of three-year-old red and white pine was commenced April 19 on approximately 420 acres on the middle and lower portions of the "Prescott Peninsula," and was confined to open areas requiring no clearing. A total of about 500,400 trees were planted and there has been but slight loss to date. Two-year-old white pine seedlings were planted early in May in a temporary nursery covering about two acres of previously cultivated land in Greenwich. A total of about 511,000 seedlings were planted with but little loss to date. Red pine and Norway spruce seedlings were planted in the latter part of May in a nursery covering about two acres in Ware east of Beaver Brook and just north of highway route 9. This area had been under cultivation the previous season and was prepared in the early spring by careful plowing and harrowing. About 288,800 red pine seedlings were planted, of which less than 50 per cent survived a fungus blight. About 53,300 Norway spruce seedlings were planted with but little loss to date. In preparation for nursery planting during the coming year, an area of four acres in Enfield adjacent to highway route 21 was plowed.

Clearing.—Outside of the lumbering operations referred to above no general clearing of the reservoir site has yet been done. However, fire stops have been established by cutting strips 100 feet wide just inside the clearing line established at the future flow line of the reservoir. Such fire stops have been cleared on the easterly slopes of the West Branch of the Swift River extending northerly from the village of Enfield, approximately 5 miles. The flow line has also been cleared on the easterly side of Beaver Brook valley for a distance of about one mile north of the dike. This work was started April 17 and continued throughout the year. Labor was engaged to clean up and burn the refuse left following the sale and removal of buildings in the towns of Prescott, Pelham, Belchertown and Enfield.

Soil Testing Laboratory.—The work of exploring, collecting and testing materials to determine their suitability for use in the construction of the proposed main dam and dike was continued. New equipment was added to the laboratory as testing methods were expanded to include new studies and to keep pace with current developments in soil engineering. Investigations were continued of the glacial deposits in prospective borrow areas north of the main dam site. Similar investigations were continued of materials at the suggested site for the East Branch baffle at Greenwich Village. Tests were continued of topsoils for impervious refill in connection with the work under Contracts 38 and 50. Routine control tests were continued to determine the density, moisture, organic content and permeability of the impervious soil refill placed under these contracts. Use of the plasticity needle was continued in these tests. Routine permeability and sizing tests were made of samples from the consolidated pervious embankments placed under Contract 38, and from the hydraulic fill constructed under Contract 50. The latter included frequent tests of the borrow pit and sluiced material and water in the pool, for the control of the quality of the beach and core materials. Tests were continued of concrete aggregates, concrete and other miscellaneous materials used in the construction work of this and other divisions.

Chemical and Bacteriological Laboratory.—The analyzing of industrial wastes and the collecting and analyzing of water samples were continued in cooperation with the headquarters office and with assistance from the Coldbrook-Swift Tunnel Division. On September 16 this division took charge of the collection of stream flow, water power and other data pertinent to mill and water power damages previously in charge of the Coldbrook-Swift Tunnel Division. Samples of water supplies of contractors engaged on work in this and other divisions and of miscellaneous supplies on property controlled by the Commission were collected and analyzed periodically.

Progress of Contracts

Contract 23.—Contract 23, for making borings in the towns of Belchertown, Enfield, Ware, Greenwich and Hardwick, was continued to completion. During the year the work consisted principally of the exploration of proposed borrow areas for materials to be used in construction.

The value of work included in contract estimates during the year was $7,331.72, the final estimate dated September 11 being for $59,044.29. The contractor had one drilling rig in operation during the year and employed an average of two men.

Under this contract 384 holes were drilled. The total depth drilled was 18,791 feet, of which 15,740 were in overburden and 3,051 in bedrock. In addition, 167 holes were abandoned by the contractor on account of the difficulty of penetration of the over-burden.

Contract 36.—Contract 36, for constructing a core wall to sound rock at the site of the dike of Quabbin Reservoir in the towns of Enfield and Ware was continued to completion. At the close of the preceding year there remained but little work to be done under this contract. A small quantity of impervious fill adjacent to the easterly end of the core wall was made and the final work of cleaning up was completed December 12, 1934. At the main dam pumping was continued under this contract in the two exploratory caissons together with pumping from exploratory caisson numbered 20, sunk under Contract 32. This pumping was taken over by the Commission December 16 when the total rate of pumpage was about 5,000 gallons per minute. The total electrical power consumed at the dike site from the beginning of the work was about 3,300,400 kilowatt hours.

The value of work included in contract estimates during the year was $48,089.34, the final estimate dated December 22, 1934, being for $1,151,602.49. The contractor's force averaged 15 men for five weeks ending January 5, the maximum being 43 for the week ending December 8, 1934.

No important items of plant were added during the year.

The total work done and materials furnished under the principal items of Contract 36 are as follows:

Earth excavation in open cut to elevation 400	284,555 cu. yds.
Earth excavation in open cut below elevation 400	53,000 " "
Rock excavation as boulders in open cut	1,610 " "
Rock excavation as ledge in open cut	4,030 " "
Stripping	85,150 " "
Unconsolidated embankment	35,420 " "
Consolidated pervious embankment	236,405 " "
Rolled impervious embankment	130,245 " "
Pumping	229,420 mil. ft. gals.
Earth excavation for core wall, bottom of open cut to elevation 310	30,065 cu. yds.
Earth excavation for core wall below elevation 310	2,000 " "
Rock excavation in caissons to elevation 310	2,025 " "
Rock excavation in caissons below elevation 310	1,060 " "
Concrete not placed under air pressure	38,855 " "
Concrete placed under air pressure	5,105 " "
Impervious filling in caisson shafts	3,435 " "
Drilling holes in rock or masonry	10,005 lin. ft.
Furnishing and placing grout	545 cu. yds.
Portland cement	72,995 bbls.
Riprap	4,575 cu. yds.

Contract 41.—Contract 41, for constructing a portion of the Belchertown-Pelham highway in the towns of Belchertown and Pelham, Hampshire County, was completed November 20, 1934.

The value of work paid for during the year was $29,418.05, the final estimate dated November 20, 1934 being for $248,578.14, of which $118,486.97, cover-

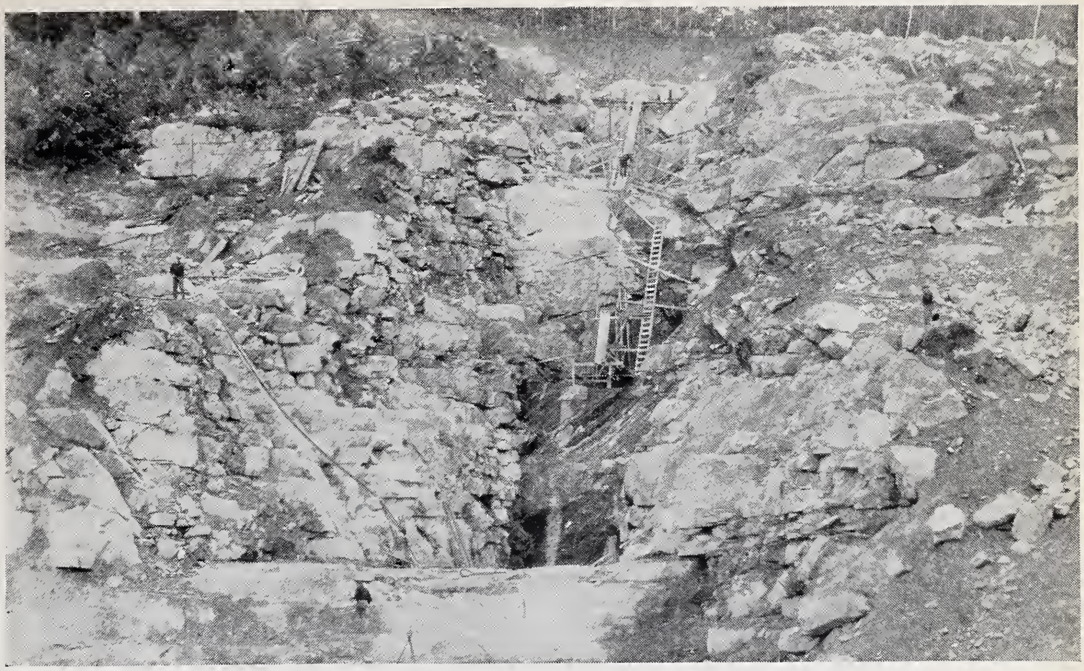
1500—12-'37. No. 2345.

CORRECTION

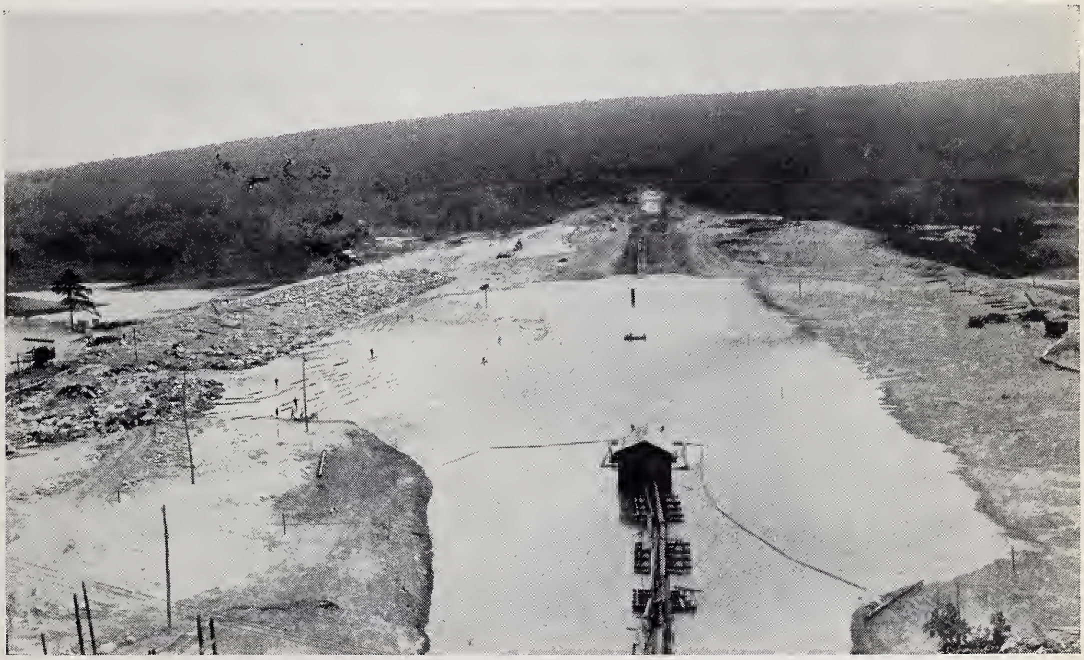
(This slip is to be inserted in the Report of the Metropolitan District Water Supply Commission, P. D. 147, 1935.)

Page 20, under Contract 23, last paragraph, last sentence.

In addition, one hole, No. 167, was abandoned by the contractor . . .



Contract 50. — Excavation for Cut-off Wall in Ledge at West End of Dike.



Contract 50. — Looking East Along Center Line of Dike Embankment Under Construction by Hydraulic Sluicing, Central Pool at Elev. 429.

ing mainly surfacing items and guard rail, was assumed by the Department of Public Works.

Contract 43.—Contract 43, for constructing an extension of the Belchertown-Pelham highway to New Salem Center in the towns of Shutesbury and New Salem, Franklin County, was practically completed early in the year. The work consisted of setting property bounds, completing guard rail, installing blind drains in wet slopes and constructing additional cobble gutters.

There has been paid the Contractor $376,964.65 and there remains to be paid in full settlement of all claims $10,640.82. The Department of Public Works has paid, mainly for surfacing items and guard rail, $101,705.13 of the above and will further reimburse the Commission in the sum of $18,862.76.

Contract 44.—Contract 44, for constructing an extension of the Belchertown-Pelham highway north of New Salem Center in the towns of New Salem and Orange, Franklin County, was completed November 20, 1934.

The value of work paid for during the year was $17,091.36, the final estimate dated November 20, 1934 being for $199,940.12, of which $63,222.73, covering mainly surfacing items and guard rail, was assumed by the Department of Public Works.

Contract 50.—Bids were opened November 13, 1934, for constructing the embankment of the dike of Quabbin Reservoir in the towns of Enfield and Ware. Six bids were received ranging from $1,446,655.00 to $2,267,962.50. The contract was executed December 5, 1934, with the Arthur A. Johnson Corporation, Long Island City, New York, the low bidder. The work under this contract includes completing the foundation work on the hillsides of the dike abutments where excavation had been started under Contract 36, placing impervious and pervious materials required to build the foundations of the dike high enough to satisfactorily permit embankment construction by the full hydraulic method, constructing the main portion of the dike by the full hydraulic method, placing riprap on the upstream face, dressing with soil and grassing the downstream face, and constructing permanent access roads.

On December 17 the contractor took over the maintenance of the engineers office at the dike site and soon after installed a new water supply for office use downstream from the dike.

On February 18 work was started on the removal of unsound ledge from the west abutment and also on the clearing of wooded areas to be used as borrow pits. Work of grading access roads was started April 1. On April 8 work was started placing rolled fills for grading preparatory to filling by hydraulic sluicing. These fills consisted of pervious material on the outer portion of the dike, semi-impervious near the core and impervious topsoil for the core in the center. For the most part these fills were placed in layers and rolled with a tractor-drawn, sheep's-foot roller, each layer after rolling being not over six inches in thickness. Extremely coarse material was placed by puddling in water. These fills were continued to practical completion during the last week in August.

Approximately 7,000 cubic yards of broken and seamy ledge was removed from the west abutment uncovering sound rock on the center line. This was covered with a fairly massive concrete blanket and the ledge thoroughly grouted. A strip of ledge was uncovered at the east abutment and a concrete blanket 20 feet wide was poured over a portion of the area uncovered during the season. The ledge encountered in the east abutment was found to be in excellent condition and it was necessary to remove but comparatively small quantities to reach sound rock. This ledge was also thoroughly grouted.

The pumping equipment which had been maintained for lowering of ground water in the high shaft of caisson 7 and in one shaft of caisson 13, as described in the previous report, was removed and all suction intakes carefully grouted. These shafts were then filled with topsoil carefully compacted. A three-foot steel cylinder equipped with observation ports was installed on top of the center shaft of caisson 13 and this cylinder is being carried up through the core to permit observation of the consolidation of the core during and after construction.

The 18-inch pipe line through the upstream cofferdam which had been installed under Contract 36 for the purpose of draining Beaver Brook through the dike site was plugged during the latter part of April. To date, Morton and

Train ponds formerly in the drainage area of Beaver Brook have not risen sufficiently high to cause a flow northerly to the Swift River. The increased elevation and capacity of Morton Pond have provided the contractor with sufficient make-up water to carry on his hydraulic fill operations.

The contractor secured most of the impervious topsoil required from a borrow area lying northeasterly and upstream from the dike, pervious materials and concrete aggregates from a borrow area southwesterly of the dike site, and the large quantity of material required for the hydraulic fill embankment from a borrow area northwesterly of and upstream from the dike. Early in the spring the contractor started work on construction roads to the various pits and prepared an area for the erection of a mixing chamber, or hog box so-called, on the westerly hillside just upstream from the center line of the dike.

The hydraulic fill was started on August 26 and continued throughout the year, the contractor working continuously except for Sundays with three eight-hour shifts. Material for the hydraulic fill was excavated by three 1¾-cubic yard shovels in the borrow pit, two electrically operated and one gasoline driven. Large boulders encountered in the pit was in general hauled to the beaches of the embankment of the dike, where they were spread in the path of the wash from the sluicing pipes and became a permanent part of the fill.

Bottom dump trucks of 8 cubic yards capacity were used for the most part in hauling material to the hog box, over which a trestle had been built with a hopper of about 20 cubic yards capacity into which the trucks were dumped. Above this hopper a grizzly of iron bars spaced about two feet apart removed the largest boulders, and below it a rotary grizzly supplied by two reciprocating feeders removed all stones greater than eight inches in diameter. The rejected stones were hauled by a gasoline-driven locomotive a short distance to a temporary dump. Material passing through the rotary grizzly entered the chute of the hog box, where it was mixed with water and distributed through the sluice pipes, alternately along the upstream and downstream shoulders of the embankment. A booster dredge pump with a capacity of 12,000 gallons per minute was installed in the sluice line near the hog box and was used continuously except during the early filling at low levels.

Water for the hog box was pumped from the pool in the core section of the dike from a pump float by three electrically operated centrifugal pumps, two of 2,000 and one of 8,000 gallons per minute capacity through a discharge line of 24-inch spiral welded pipe. Prior to the operation of sluicing, the core pool was filled by a pump of 2,000 gallons per minute capacity located upstream from the dike on Morton Pond. The deficiency in water in the core pool was made up from time to time by this pump.

The discharge sluice lines to the beaches from the hog box and dredge pump consisted of 20-inch slip-joint steel pipe. As a rule, the discharge was carried across the valley throughout the length of one beach by adding or taking off one length of pipe at a time before shifting to the other beach for a similar operation. The discharge lines being on the shoulder or outer limits of the beaches, coarse material deposited near the pipe discharge was moved by draglines to form a suitable levee along the outer slope of the embankment in advance of the sluicing. Other materials were deposited varying in size from gravel near the discharge lines to fine sand near the limits of the pool, the extreme fine material going into the core pool to be settled out as the core of the dike. Velocities on the beaches were controlled by the use of numerous baffle boards to prevent gullying of the beach and to secure a proper gradation of materials. By the end of the year approximately 25 per cent of the material required to be placed by hydraulic methods had been placed in the embankment. The greater part of the westerly access road to the top of the dike and of the easterly access road leading to the easterly end of the dike was graded.

The value of work included in contract estimates to November 15, the date of the latest estimate, was $400,463.00, of which 90 per cent was approved for payment. The contractor's force averaged 119 men, the maximum being 212 for the week ending November 2. Camp facilities have not been provided at the work.

Electric power for all contract requirements was purchased by the contractor. The total consumed was approximately 1,225,700 kilowatt hours.

The principal items of plant were as follows:

3	Gasoline and 2 electric shovels
1	Traveling crane
13	Trucks, mostly 8 cu. yd., bottom dump
3	Bulldozers
2	Sheep's-foot rollers
1	Hog box with twin horizontal feed to rotary grizzly
1	20-inch dredge pump, 12,000 gals. per min. capacity, driven by 1,000 H.P. electric motor
1	Pump float
4	Electrically driven centrifugal pumps, varying in capacity from 2,000 gals. per min. at 90 ft. head to 8,000 at 120 ft. head
4,000	Feet 20-inch pipe slip joints, 20-ft. lengths
1,800	Feet of spiral welded pipe from 10 to 24 inches diameter
1	Crushing, screening and washing plant
1	1-Cu. yd. concrete paver
	Gasoline locomotives, dump cars, etc.

The total work done and materials furnished to date under the principal items of Contract 50 are as follows:

Clearing and grubbing	65	acres
Earth excavation	37,000	cu. yds.
Rock excavation for core wall	7,150	" "
Rock excavation except for core wall	2,100	" "
Consolidated pervious foundation embankment	155,400	" "
Rolled impervious embankment in core	47,400	" "
Rolled impervious embankment except in core	61,000	" "
Embankment by full hydraulic method	518,500	" "
Miscellaneous embankment	9,400	" "
Selected coarse material	19,000	" "
Crushed stone or screened gravel	2,000	" "
Gravel sub-base for roads	1,500	" "
Furnishing and placing grout	540	" "
Portland cement	7,980	bbls.
Concrete, Class A	3,430	cu. yds.
Concrete, Class B	15	" "
Miscellaneous steel and iron	24,800	lbs.

Boston and Albany Railroad—Athol Branch.—Under its agreement with the Commission for the removal of tracks in the Quabbin Reservoir area, the Boston and Albany Railroad Company discontinued the public use of the Athol Branch from Bondsville to Athol June 1 on which date the last public train was operated over this line.

Work of removal of rails and appurtenances of salvage value was started June 3, at the Athol end of the line and completed July 31, to a point 0.78 mile northerly from the West Ware railroad station and located 0.10 mile below the site of the main dam. A total of approximately 23.9 miles of the line has been removed effecting complete removal in the Quabbin Reservoir area.

The line from Bondsville to the main dam is being maintained in order that equipment and materials to be used in construction work may be brought in by rail.

Throughout its operation of removal an average of 35 men were employed by the railroad company.

Geological Data

Chapter 321, Acts of 1927, provides that "The Commission shall collect and publish in its reports such information as to the geology of the region in which any of the works which it is authorized to construct may be located as may be of value in connection with the geological history of the State." A geological report is appended hereto.

List of Drawings and Tables Appended Hereto

Location of Real Estate Acquired for Quabbin Reservoir.
Takings of Real Estate (and Water Rights).
Status of Contracts Completed between November 30, 1934, and November 30, 1935; and in Force on November 30, 1935.
Canvass of Bids; Contract 38.
Canvass of Bids; Contract 49.
Construction Progress Coldbrook-Swift Tunnel Section of Quabbin Aqueduct.
Monthly Rainfall at Stations on Ware and Swift Watersheds, 1935.
Summary of Rainall on Ware and Swift Watersheds.

For data on contracts completed prior to November 30, 1934, see sixth to ninth annual reports, inclusive. A General Plan and Profile of the Present and Proposed Metropolitan Water Supply is included in the appended geological report.

Respectfully submitted,
FRANK E. WINSOR, *Chief Engineer.*

20 Somerset Street, Boston, Mass.
January 2, 1936.

FINANCIAL STATEMENT OF THE METROPOLITAN DISTRICT WATER SUPPLY COMMISSION

EXPENDITURES AND DISBURSEMENTS FOR THE FISCAL YEAR AND FROM JULY 28, 1926, THE DATE OF THE APPOINTMENT OF THE COMMISSION

GENERAL OVERHEAD

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
ADMINISTRATION, *Commissioners' Office:*		
Salaries, Commissioners	$10,500.00	$96,415.57
Salaries, Clerical	11,847.31	96,614.21
General Legal Expense	0.00	1,502.80
Furniture and Fixtures	116.67	2,926.22
Rent and Upkeep	2,337.12	20,491.79
Automobile Purchase	0.00	2,464.90
Automobile Maintenance	256.82	2,729.71
Miscellaneous Expense (undistributed)	1,123.80	13,073.27
Advertising	1,853.40	7,994.35
Printing and Blueprinting	680.26	9,131.38
Stationery and Office Supplies	241.94	2,085.15
Postage	132.00	1,129.30
Total Administration, Commissioners' Office	$29,089.32	$256,558.65
ENGINEERING, *Headquarters' Office:*		
Salaries, Engineering	$81,223.76	$700,441.24
Salaries, Clerical	9,634.13	83,595.33
General Consultant Expense	0.00	116,515.25
General Legal Expense	0.00	53,160.29
Furniture and Fixtures	344.15	14,094.29
Laboratory Equipment	0.00	1,961.00
Laboratory Supplies	0.00	2,071.94
Rental of Equipment	0.00	3,370.02
Engineering Instruments	1.43	1,084.06
Rent and Upkeep of Boston Office	10,323.71	93,703.47
Rent and Upkeep of Springfield Laboratory	0.00	3,950.54
Automobile Purchase	0.00	3,151.60
Automobile Maintenance	255.73	3,617.99
Special Experiments	0.00	2,304.63
Miscellaneous Expense (undistributed)	559.69	20,668.87
Printing and Blueprinting	550.97	13,938.10
Stationery and Office Supplies	498.49	5,075.22
Postage	277.00	1,808.58
Total Engineering, Headquarters' Office	$103,669.06	$1,124,512.42
UNASSIGNED:		
Unassigned Supplies and Equipment	$393.54	$956.96
Total Unassigned	$393.54	$956.96
Total General Overhead	$133,151.92	$1,382,028.03

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
DISTRIBUTION OF GENERAL OVERHEAD		
ADMINISTRATION, *Commissioners' Office:*		
Wachusett-Coldbrook Tunnel	$3,400.21	$76,080.12
Coldbrook-Swift Tunnel	6,135.66	27,961.78
Quabbin Reservoir	10,309.56	95,450.20
Main Dam	5,290.70	23,675.89
Beaver Brook Dike	3,953.19	24,700.38
Southern Sudbury Emergency Supply	0.00	8,690.28
Total Administration, Commissioners' Office	$29,089.32	$256,558.65
ENGINEERING, *Headquarters' Office:*		
Wachusett-Coldbrook Tunnel	$12,367.86	$305,927.46
Coldbrook-Swift Tunnel	20,834.70	108,043.44
Quabbin Reservoir	36,392.20	496,715.55
Main Dam	20,023.83	87,533.11
Beaver Brook Dike	14,050.47	92,884.89
Southern Sudbury Emergency Supply	0.00	33,407.97
Total Engineering, Headquarters' Office	$103,669.06	$1,124,512.42

WACHUSETT-COLDBROOK TUNNEL SECTION OF QUABBIN AQUEDUCT, WARE SUPPLY

GENERAL OVERHEAD:		
Administration	$3,400.21	$76,080.12
Engineering	12,367.86	305,927.46
Total General Overhead	$15,768.07	$382,007.58
ENGINEERING:		
Salaries, Engineering and Clerical	$1,483.13	$394,373.50
Consultant Expense	37.50	7,649.86
Labor	6.00	2,015.33
Furniture and Fixtures	0.00	2,240.89
Engineering Instruments	–200.00	7,555.47
Rent and Upkeep	32.14	16,804.36
Automobile Purchase	157.00	11,422.82
Automobile Maintenance	80.72	15,178.90
Contracts for Investigations and Surveys	0.00	18,640.69
Miscellaneous Expense (undistributed)	23.56	9,201.91
Advertising	0.00	6.05
Printing and Blueprinting	1.06	1,058.93
Stationery and Office Supplies	2.90	2,965.93
Postage	0.00	434.81
Total Engineering	$1,624.01	$489,549.45
REAL ESTATE, *General Construction:*		
Legal and Expert Expense	$337.26	$6,186.92
Consultant Expense	0.00	455.66
Labor	86.70	1,711.20
Miscellaneous Expense (undistributed)	0.00	1,003.60
Printing and Blueprinting	10.54	60.92
Purchases and Settlements	0.00	122,989.16
Taxes	228.36	3,494.03
Maintenance of Real Estate	114.03	1,107.97
Police Protection, Labor	0.00	41.00
Fire Protection, Equipment	0.00	30.97
Miscellaneous Expense	0.00	0.54

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Special Agents, Salaries	$0.00	$12,949.00
Furniture and Fixtures	0.00	117.67
Automobile Purchase	0.00	1,222.50
Automobile Maintenance	0.00	2,124.30
Miscellaneous Expense (undistributed)	0.00	1,201.73
Printing and Blueprinting	0.00	26.51
Stationery and Office Supplies	0.00	5.48
Postage	0.00	21.36
Total Real Estate	$776.89	$154,750.52
WARE WATERSHED PROTECTION:		
Salaries, Engineering and Clerical	$11,562.33	$112,165.79
Legal and Expert Expense	1,525.59	16,238.13
Consultant Expense	0.00	763.70
Labor	264.00	9,522.24
Engineering Instruments	27.89	317.14
Completed Contract No. 27	0.00	4,395.51
Contract No. 39, Rutland-Holden Sewer	46,184.76	238,708.67
Automobile Purchase	24.50	568.45
Automobile Maintenance	536.83	3,702.73
Special Experiments	0.00	700.00
Miscellaneous Expense (undistributed)	373.41	4,699.01
Advertising	2.00	2.00
Printing and Blueprinting	12.14	470.21
Stationery and Office Supplies	5.60	97.94
Postage	16.85	16.85
Installed Equipment	158.19	5,610.75
Purchases and Settlements	26,499.70	1,082,745.19
Taxes	8,659.00	28,085.41
Maintenance of Real Estate	1,577.41	1,753.82
Special Agents, Salaries	2,460.00	4,728.67
Rent and Upkeep	48.86	48.86
Automobile Purchase	303.35	303.35
Automobile Maintenance	456.56	966.24
Miscellaneous Expense (undistributed)	291.60	549.51
Printing and Blueprinting	3.19	3.19
Stationery and Office Supplies	0.76	1.91
Postage	7.50	13.50
Rutland-Holden Sewer, Maintaining, Cleaning and Repairing		
State Sanatorium Branch	337.50	349.61
U. S. Vet. Hospital Branch	349.91	367.63
Trunk Sewer, except Branches	816.90	833.58
Total Ware Watershed Protection	$102,506.33	$1,518,729.59
WARE DIVERSION DAMAGES — EXCEPT JURY TRIAL:		
*Salaries, Engineering and Clerical	$-2,488.38	$82,160.39
Legal and Expert Expense	72.50	3,171.83
*Consultant Expense	-3,870.14	23,988.45
Labor	31.45	2,310.69
Furniture and Fixtures	0.25	24.41
Laboratory Equipment	36.21	186.35
Laboratory Supplies	77.23	286.94
Engineering Instruments	46.00	557.94
Rental of Equipment	0.00	203.75

---

* Expenditures previously carried in these accounts and applying to cases assigned for trial during the year have been transferred to corresponding Jury Trial accounts.

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Rent and Upkeep	$0.13	$0.13
Automobile Purchase	25.04	170.42
Automobile Maintenance	390.46	3,425.39
Contracts for Investigations and Surveys	0.00	63.27
Materials of Construction	0.00	136.51
Miscellaneous Expense (undistributed)	292.75	7,255.68
Printing and Blueprinting	154.52	1,232.34
Stationery and Office Supplies	34.84	59.12
Postage	0.00	6.62
Purchases and Settlements	1,300.00	166,525.00
Sub Total Ware Diversion Damages — Except Jury Trial	$-3,897.14	$291,765.23
WARE DIVERSION DAMAGES — JURY TRIAL:		
Salaries, Engineering and Clerical	$28,297.91	$41,524.60
Legal Expense	5,041.34	16,117.47
Consultant Expense	20,762.96	35,985.52
Expert and other Witness Expense	0.00	10,541.97
Automobile Maintenance	27.75	72.11
Miscellaneous Expense (undistributed)	706.94	2,396.74
Printing and Blueprinting	248.19	248.19
Settlements	0.00	260,000.00
Payments under Certificates of Judgment	190,208.95	190,208.95
Sub Total Ware Diversion Damages — Jury Trial	$245,294.04	$557,095.55
Total Ware Diversion Damages	241,396.90	848,860.78
PERMANENT CONSTRUCTION — CONSTRUCTION CONTRACTS:	$0.00	$9,629,739.99
PERMANENT CONSTRUCTION — EXCEPT CONSTRUCTION CONTRACTS:		
Installed Equipment	$0.00	$59,018.10
Temporary Equipment	0.00	6,423.60
Labor	427.20	4,060.44
Contracts for Equipment for Surveys	0.00	898.34
Maintenance of Partially Completed Structures	1,520.65	8,966.24
Maintenance of Grounds	852.57	3,638.86
Purchase of Plants, Trees and Shrubbery	0.00	842.58
Rental of Equipment	0.00	7.00
Miscellaneous Expense	0.00	9,453.84
Total	$2,800.42	$93,309.00
Total Wachusett-Coldbrook Tunnel, Ware Supply	$364,872.62	$13,116,946.91

SPECIAL INVESTIGATION — POLLUTION OF WARE AND QUINAPOXET WATERSHEDS
(Expenditures under Chapter 66, Resolves of 1931)

Total Special Investigation	$0.00	$1,995.99

WACHUSETT WATERSHED PROTECTION

ENGINEERING:		
Salaries, Engineering and Clerical	$2,138.57	$2,138.57
Legal Expense	3.55	3.55
Labor	27.20	27.20

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Automobile Maintenance	$47.33	$47.33
Miscellaneous Expense (undistributed)	216.03	216.03
Printing and Blueprinting	6.50	6.50
Total Wachusett Watershed Protection	$2,439.18	$2,439.18
COLDBROOK-SWIFT TUNNEL SECTION OF QUABBIN AQUEDUCT		
GENERAL OVERHEAD:		
Administration	$6,135.66	$27,961.78
Engineering	20,834.70	108,043.44
Total General Overhead	$26,970.36	$136,005.22
ENGINEERING:		
Salaries, Engineering and Clerical	$37,530.81	$250,306.75
Consultant Expense	78.63	412.75
Labor	276.00	812.25
Furniture and Fixtures	250.00	1,020.91
Engineering Instruments	13.59	4,551.29
Rent and Upkeep	1,242.02	10,268.98
**Rental of Equipment	0.00	3.00
Automobile Purchase	–125.00	8,010.52
Automobile Maintenance	1,841.10	17,326.49
Contracts for Investigations and Surveys	0.00	13,525.66
Materials of Construction	0.00	2.25
Miscellaneous Expense (undistributed)	310.52	7,644.99
Printing and Blueprinting	98.84	909.57
Stationery and Office Supplies	96.75	2,095.54
Postage	60.73	505.29
Total Engineering	$41,673.99	$317,396.24
REAL ESTATE:		
Legal and Expert Expense	$15.27	$3,099.64
Labor	0.00	12.20
Miscellaneous Expense (undistributed)	0.00	27.16
Printing and Blueprinting	0.00	34.87
Postage	0.00	5.68
Purchases and Settlements	0.00	22,585.00
Taxes	257.48	724.77
Maintenance of Real Estate	0.00	24.85
Fire Protection, Equipment	0.00	60.86
Total Real Estate	$272.75	$26,575.03
PERMANENT CONSTRUCTION — CONSTRUCTION CONTRACTS:		
Contract No. 20, Construction of Coldbrook-Swift Tunnel	$365,790.78	$4,809,852.83
Total Contracts	$365,790.78	$4,809,852.83
PERMANENT CONSTRUCTION — EXCEPT CONSTRUCTION CONTRACTS:		
Labor	$244.20	$308.95
Installed Equipment	371.70	489.34
**Water Supply System	3,203.04	3,222.24
Miscellaneous Expense	148.47	2,487.43
Total	$3,967.41	$6,507.96
Total Coldbrook-Swift Tunnel	$438,675.29	$5,296,337.28

** This expenditure was previously carried under Miscellaneous Expense.

QUABBIN RESERVOIR EXCEPT MAIN DAM AND DIKE

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
GENERAL OVERHEAD:		
Administration	$10,309.56	$95,450.20
Engineering	36,392.20	496,715.55
Total General Overhead	$46,701.76	$592,165.75
ENGINEERING:		
Salaries, Engineering and Clerical	$53,425.52	$366,343.26
Consultant Expense	0.00	228.23
Labor	3,765.45	10,984.14
Furniture and Fixtures	49.85	3,066.88
Laboratory Equipment	367.93	1,378.24
Laboratory Supplies	792.37	2,727.72
Rental of Equipment	0.00	16.75
Engineering Instruments	–57.82	6,344.46
Rent and Upkeep	1,249.62	8,295.65
Automobile Purchase	2,129.46	17,165.85
Automobile Maintenance	2,144.31	15,273.96
Special Experiments	0.00	422.80
Contracts for Investigations and Surveys	678.09	12,746.63
Office Buildings	137.62	5,053.16
Miscellaneous Expense (undistributed)	882.31	5,620.71
Printing and Blueprinting	316.19	2,052.87
Stationery and Office Supplies	578.91	5,531.87
Postage	186.50	1,091.64
Total Engineering	$66,646.31	$464,344.82
REAL ESTATE — EXCEPT BOARD OF REFEREES AND JURY TRIAL:		
Legal and Expert Expense	$9,279.14	$152,968.37
Consultant Expense	146.78	146.78
Labor	245.80	341.15
Furniture and Fixtures	0.00	15.68
Automobile Maintenance	14.42	14.42
Miscellaneous Expense (undistributed)	1,494.39	7,045.66
Advertising	0.00	208.66
Printing and Blueprinting	29.66	1,316.46
Stationery and Office Supplies	0.00	0.45
Purchases and Settlements	279,462.56	6,176,998.52
Purchase, part of Athol Branch, Boston & Albany Railroad	*575,000.00	*575,000.00
Taxes	67,906.89	291,468.58
Maintenance of Real Estate	2,256.20	6,536.93
Water Supply System	0.00	40.60
Fire Protection, Labor	383.50	410.70
Tools and Equipment	1,237.47	4,790.30
Automobile Purchase	0.00	771.69
Automobile Maintenance	23.19	280.33
Miscellaneous Expense	41.29	171.02
Police Protection, Labor	0.00	14.00
Special Agents, Salaries	2,460.00	18,026.00
Equipment	0.00	118.33
Automobile Purchase	303.35	1,540.31
Automobile Maintenance	335.51	3,053.30
Miscellaneous Expense (undistributed)	157.60	1,247.03
Printing and Blueprinting	11.12	52.72
Stationery and Office Supplies	1.08	10.41

* This entry made by order of the Comptroller of the Commonwealth.

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Postage	$3.45	$17.07
Renting Agents, Salaries	2,820.00	20,888.10
Legal Expense	60.00	60.00
Furniture and Fixtures	0.00	29.29
Miscellaneous Expense (undistributed)	125.07	611.03
Printing and Blueprinting	0.00	18.62
Stationery and Office Supplies	1.75	35.16
Postage	14.71	129.59
Payments to Towns	2,000.00	14,500.00
Sub Total Real Estate — Except Board of Referees and Jury Trial	$945,814.93	$7,278,877.26
REAL ESTATE — BOARD OF REFEREES:		
Salaries of Referees	$0.00	$6,940.00
Salaries, Engineering and Clerical	0.00	967.88
Legal Expense	698.57	4,823.53
Consultant Expense	0.00	622.40
Expert and other Witness Expense	0.00	4,510.07
Expenses of Board of Referees	0.00	550.30
Miscellaneous Expense	0.00	45.78
Sub Total Real Estate — Board of Referees	$698.57	$18,459.96
REAL ESTATE — JURY TRIAL:		
Salaries, Engineering and Clerical	$0.00	$27.73
Legal Expense	301.85	471.18
Miscellaneous Expense	2.00	2.00
Payments under Certificates of Judgment	7,751.87	7,751.87
Sub Total Real Estate — Jury Trial	$8,055.72	$8,252.78
Total Real Estate	$954,569.22	$7,305,590.00
QUABBIN RESERVOIR DAMAGES:		
Salaries, Engineering	$0.00	$48.68
Legal and Expert Expense	0.00	931.00
Consultant Expense	0.00	2,158.82
Miscellaneous Expense	0.00	18.15
Purchases and Settlements	265.00	45,675.00
Total Quabbin Reservoir Damages	$265.00	$48,831.65
SWIFT DIVERSION DAMAGES:		
Salaries, Engineering and Clerical	$2,644.23	$68,402.31
Legal and Expert Expense	63.69	5,646.52
Consultant Expense	8,490.83	69,854.17
Labor	283.05	421.19
Furniture and Fixtures	2.21	39.72
Laboratory Equipment	325.74	1,292.56
Laboratory Supplies	694.19	2,347.72
Engineering Instruments	0.84	741.45
Rent and Upkeep	1.15	1.15
Rental of Equipment	0.00	10.50
Automobile Purchase	225.31	1,533.72
Automobile Maintenance	1,019.10	3,154.02
Contracts for Investigations and Surveys	0.00	569.47
Materials of Construction	0.00	18.99
Miscellaneous Expense (undistributed)	119.50	6,057.37
Printing and Blueprinting	85.44	973.25

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Stationery and Office Supplies	$13.12	$41.01
Purchases and Settlements	0.00	942,975.00
Total Swift Diversion Damages	$13,968.40	$1,104,080.12
QUABBIN RESERVOIR — CEMETERIES		
QUABBIN PARK CEMETERY CONSTRUCTION:		
Salaries, Engineering and Clerical	$420.00	$11,564.27
Legal and Expert Expense	0.00	65.00
Consultant Expense	0.00	125.00
(Construction) Labor	2,422.40	13,409.75
Tools and Equipment	10.03	93.99
Automobile Purchase	0.00	1,615.37
Automobile Maintenance	208.43	1,275.18
Rental of Equipment	0.00	33.19
Purchases and Settlements	0.00	8,850.00
Construction Materials	90.55	1,644.76
Purchase and Planting of Trees and Shrubbery	0.00	218.93
Receiving Vault	0.00	2,768.85
Water Supply System	0.00	1,251.97
Maintenance of Grounds	1,440.03	4,756.29
Miscellaneous Expense (undistributed)	18.79	175.65
Printing and Blueprinting	0.00	159.08
Stationery and Office Supplies	1.02	10.05
Completed Contract No. 34	0.00	7,842.94
Sub Total Quabbin Park Cemetery Construction	$4,611.25	$55,860.27
REMOVALS FROM CEMETERIES WITHIN RESERVOIR AREA TO QUABBIN PARK CEMETERY:		
Salaries, Engineering and Clerical	$2,210.50	$6,939.09
Tools and Equipment	26.24	438.38
Automobile Purchase	0.00	2,669.99
Automobile Maintenance	316.68	1,099.89
Removal and Reinterment of Bodies	2,949.25	10,188.53
Removal and Resetting of Monuments	1,776.96	6,722.98
Miscellaneous Expense	0.00	2.00
Rental of Equipment	0.00	10.50
Sub Total Removals to Quabbin Park Cemetery	$7,279.63	$28,071.36
REMOVALS FROM CEMETERIES WITHIN RESERVOIR AREA TO CEMETERIES OTHER THAN QUABBIN PARK:		
Salaries, Engineering and Clerical	$140.75	$5,856.49
Automobile Purchase	0.00	380.00
Automobile Maintenance	27.97	90.06
Purchases and Settlements	196.00	6,959.10
Perpetual Care Fund Contributions	0.00	175.00
Removal and Reinterment of Bodies	377.50	6,467.45
Removal and Resetting of Monuments	219.60	5,717.34
Miscellaneous Expense	5.60	123.51
Sub Total Removals to Other Cemeteries	$967.42	$25,768.95
Total Quabbin Reservoir Cemeteries	$12,858.30	$109,700.58

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
PERMANENT CONSTRUCTION — CONSTRUCTION CONTRACTS:		
Contract No. 49, Excavating Diversion Channels	$6,570.00	$6,570.00
Total Contracts	$6,570.00	$6,570.00
PERMANENT CONSTRUCTION — EXCEPT CONSTRUCTION CONTRACTS:		
Installed Equipment	$0.00	$214.78
Reservoir Clearing, Labor	571.00	571.00
Tools and Equipment	286.12	286.12
Automobile Maintenance	46.09	46.09
Miscellaneous Expense	3.05	3.05
Total	$906.26	$1,121.04
HIGHWAY AND PUBLIC UTILITY RELOCATION:		
Salaries, Engineering and Clerical	$20,280.31	$158,003.53
Legal and Expert Expense	0.00	49.10
Consultant Expense	4.60	8,454.75
Labor	2,355.20	6,008.41
Furniture and Fixtures	0.00	61.74
Completed Contracts Nos. 21 and 40	0.00	284,770.35
Contract No. 41, Construction of about 9.1 miles of the Belchertown-Pelham Highway in Belchertown and Pelham	23,810.83	130,091.17
Contract No. 43, Construction of about 7.6 miles of Extension of Belchertown-Pelham Highway in Shutesbury and New Salem to New Salem Center	118,871.15	275,259.52
Contract No. 44, Construction of about 4.1 miles of Extension of Belchertown-Pelham Highway in New Salem and Orange	$34,175.12	$136,717.39
Installed Equipment	0.00	811.57
Temporary Equipment	0.00	149.50
Engineering Instruments	0.00	625.14
Automobile Purchase	0.00	535.00
Automobile Maintenance	550.54	4,482.86
Miscellaneous Expense (undistributed)	896.99	4,639.93
Printing and Blueprinting	2.96	292.49
Stationery and Office Supplies	0.00	90.34
Maintenance of Real Estate	551.60	551.60
Total Highway and Public Utility Relocation	$201,499.30	$1,011,594.39
QUABBIN RESERVOIR WATERSHED PROTECTION REFORESTATION:		
Nurseries; Salaries, Engineering	$144.15	$144.15
Labor	2,014.35	2,014.35
Tools and Equipment	62.06	62.06
Automobile Maintenance	35.98	35.98
Miscellaneous Expense	8.50	8.50
Watershed; Saleries, Engineering	280.76	280.76
Labor	5,490.90	5,490.90
Tools and Equipment	165.63	165.63
Automobile Maintenance	9.22	9.22
Miscellaneous Expense	61.01	61.01
Sub Total Reforestation	$8,272.56	$8,272.56
Total Quabbin Reservoir Watershed Protection	$8,272.56	$8,272.56
Total Quabbin Reservoir, Except Main Dam and Dike	$1,312,257.11	$10,652,270.91

QUABBIN RESERVOIR MAIN DAM

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
GENERAL OVERHEAD:		
Administration	$5,290.70	$23,675.89
Engineering	20,023.83	87,533.11
Total General Overhead	$25,314.53	$111,209.00
ENGINEERING:		
Salaries, Engineering and Clerical	$42,484.24	$117,955.01
Consultant Expense	75.75	5,154.26
Labor	5,540.15	10,833.63
Furniture and Fixtures	66.76	130.94
Laboratory Equipment	9.73	453.77
Rental of Equipment	782.25	1,202.25
Engineering Instruments	214.93	416.49
Rent and Upkeep	383.16	703.24
Automobile Purchase	295.00	1,495.00
Automobile Maintenance	1,801.15	3,006.00
Contracts for Investigations and Surveys	6,391.71	58,620.92
Office Buildings	328.39	578.39
Special Experiments	32.40	1,600.89
Water Supply System	0.00	20.00
Miscellaneous Expense (undistributed)	892.05	11,425.48
Printing and Blueprinting	633.96	698.11
Stationery and Office Supplies	465.39	610.44
Postage	51.93	52.48
Total Engineering	$60,448.95	$214,957.30
PERMANENT CONSTRUCTION — CONSTRUCTION CONTRACTS:		
Completed Contracts Nos. 30 and 32	$0.00	$593,001.41
Contract No. 36, Constructing Exploratory Caissons at Main Dam	43,439.63	211,912.11
Contract No. 38, Constructing a Core Wall to Sound Rock at Main Dam	919,646.10	919,646.10
Total Contracts	$963,085.73	$1,724,559.62
PERMANENT CONSTRUCTION — EXCEPT CONSTRUCTION CONTRACTS:		
Labor	$961.90	$3,453.70
Installed Equipment	0.00	3,253.00
Temporary Equipment	0.00	4,213.39
Miscellaneous Expense	9,802.35	12,098.50
Total	$10,764.25	$23,018.59
Total Quabbin Reservoir Main Dam	$1,059,613.46	$2,073,744.51

QUABBIN RESERVOIR BEAVER BROOK DIKE

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
GENERAL OVERHEAD:		
Administration	$3,953.19	$24,700.38
Engineering	14,050.47	92,884.89
Total General Overhead	$18,003.66	$117,585.27
ENGINEERING:		
Salaries, Engineering and Clerical	$33,798.97	$100,877.96
Consultant Expense	116.87	4,940.84
Labor	3,260.32	8,186.24
Furniture and Fixtures	0.00	127.22
Laboratory Equipment	0.00	315.73

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Rental of Equipment	$0.00	$921.50
Engineering Instruments	64.62	116.89
Rent and Upkeep	0.00	16.00
Automobile Purchase	0.00	600.00
Automobile Maintenance	566.85	1,853.67
Contracts for Investigations and Surveys	471.26	24,080.73
Special Experiments	1.60	55.20
Miscellaneous Expense	194.95	4,760.56
Printing and Blueprinting	7.52	1,278.75
Stationery and Office Supplies	95.80	158.99
Advertising	0.00	79.34
Total Engineering	$38,578.76	$148,369.62
PERMANENT CONSTRUCTION — CONSTRUCTION CONTRACTS:		
Completed Contract No. 32	$0.00	$114,447.52
Contract No. 36, Constructing a Core Wall to Sound Rock at Dike	115,001.02	939,690.38
Contract No. 50, Constructing the Embankment of the Dike	360,578.70	360,578.70
Total Contracts	$475,579.72	$1,414,716.60
PERMANENT CONSTRUCTION — EXCEPT CONSTRUCTION CONTRACTS:		
Labor	$333.30	$9,757.25
Temporary Equipment	1,687.53	1,993.18
Tools and Equipment	0.00	14.70
Miscellaneous Expense	86.49	1,648.53
Total	$2,107.32	$13,413.66
Total Quabbin Reservoir Beaver Brook Dike	$534,269.46	$1,694,085.15

SOUTHERN SUDBURY EMERGENCY SUPPLY

GENERAL OVERHEAD	$0.00	$42,098.25
ENGINEERING	0.00	44,235.07
REAL ESTATE	0.00	30,553.18
SOUTHERN SUDBURY DIVERSION DAMAGES	0.00	50,752.66
PERMANENT CONSTRUCTION — CONSTRUCTION CONTRACTS	0.00	458,957.30
PERMANENT CONSTRUCTION — EXCEPT CONSTRUCTION CONTRACTS	0.00	11,937.37
Total Southern Sudbury Emergency Supply	$0.00	$638,533.83

SUMMARY

Wachusett-Coldbrook Tunnel, Ware Supply	$364,872.62	$13,116,946.91
Special Investigation — Pollution of Ware and Quinapoxet Watersheds	0.00	1,995.99
Wachusett Watershed Protection	2,439.18	2,439.18
Coldbrook-Swift Tunnel	438,675.29	5,296,337.28
Quabbin Reservoir except Main Dam and Dike	1,312,257.11	10,652,270.91
Quabbin Reservoir Main Dam	1,059,613.46	2,073,744.51
Quabbin Reservoir Beaver Brook Dike	534,269.46	1,694,085.15
Southern Sudbury Emergency Supply	0.00	638,533.83
Unassigned	393.54	956.96
Grand total	$3,712,520.66	$33,477,310.72

RECEIPTS FROM RENTS, SALES, ETC.

	Year ending Nov. 30, 1935	Total to Nov. 30, 1935
Sales	$49,890.99	$182,922.01
Rents	47,574.12	351,875.35
Miscellaneous	97,355.70	102,631.73
Total Receipts	$194,820.81	$637,429.09

COMMONWEALTH OF MASSACHUSETTS

METR. DISTR. WATER SUPPLY COMMISSION

LOCATION OF REAL ESTATE ACQUIRED FOR THE QUABBIN RESERVOIR

(TITLE VESTED IN COMMONWEALTH)

Towns	Total - Nov. 30, 1934.		Total for Year Ending Nov. 30, 1935 (Acres)	Total Nov. 30, 1935 (Acres)	Remarks
	1934 Annual Report (Acres)	Revised - See Note (Acres) *			
Belchertown	2,803	2,804	68	2,872	* *Revisions have been made using acreages obtained from surveys wherever available, otherwise from deeds, property blanks, etc.*
Dana	8,236	8,236	294	8,530	
Enfield	7,831	7,830	808	8,638	
Greenwich	10,475	10,476	121	10,597	
Hardwick	2,975	2,974	59	3,033	
New Salem	7,983	7,995	1,591	9,586	
Orange	1	1	20	21	
Pelham	4,567	4,567	153	4,720	
Petersham	719	720	85	805	
Prescott	10,227	10,227	280	10,507	
Shutesbury	2,625	2,623	483	3,106	
Ware	722	713	116	829	
Wendell	36	37	223	260	
Totals	59,200	59,203	4,301	63,504	

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

TAKINGS OF REAL ESTATE (AND WATER RIGHTS)

TAKING FOR	TAK-ING NO.	TOWN	COUNTY	DATE OF TAKING	PLAN NO.	TITLE VESTED IN COMMONWEALTH	
						FEE (Acres)	EASEMENT (Acres)
Southern Sudbury Emergency Supply.	1 to 9 incl.	Details previously reported in the 1930 Annual Report.			C-1 to C-15 incl.	258.81 (Also Water Rights)	29.02
Wachusett-Coldbrook Tunnel section of Quabbin Aqueduct.	1 to 4 incl.	Details previously reported in the 1930 Annual Report.			T-1 to T-13 incl.	570.22	20.37
Coldbrook-Swift Tunnel section of Quabbin Aqueduct.	1 to 3 incl.	Details previously reported in the 1931 Annual Report. *(391.42 acres of this total are within the Quabbin Reservoir Area)			T-14 to T-27 incl.	*544.81	4.06
Quabbin Reservoir.	1 to 13 incl.	Details previously reported in the 1931, 1932, 1933 and 1934 Annual Reports.			S-1 to S-28 incl.	637.01	19.85
" " (Taking of Waters of Beaver Brook above Dike of Quabbin Reservoir.)	—	Enfield	Hampshire	Mar. 22, 1935.	None	Water Rights	
Ware River Supply and Watershed.	1 to 2 incl.	Details previously reported in the 1932 and 1933 Annual Reports.			W-1 and A-1 to A-14 incl.	0.25	22.94
	—	Details previously reported in the 1931 Annual Report.			None	Water Rights	

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

STATUS OF CONTRACTS COMPLETED BETWEEN NOV. 30, 1934 AND NOV. 30, 1935

CONT. NO.	DESCRIPTION	LOCATION	SUPPLY	CONTRACTOR	BIDS OPENED	NO. OF BIDS	CONTRACT AWARDED	BASIS OF AWARD	FINAL ESTIMATE	DATE OF FINAL EST.
20	Coldbrook-Swift Tunnel.	Barre, Hardwick and Greenwich	Swift	Wenzel & Henoch, Construction Co.	Mar. 27, 1931	13	April 10, 1931	$4,978,031.80	$4,809,852.83	Oct. 1, 1935
23	Making Borings.	Belchertown, Ware, Enfield, Greenwich & Hardwick	Swift	Sprague & Henwood, Inc.	Nov. 5, 1929	6	Nov. 5, 1929	10,950.00	59,044.29	Sept. 11, 1935
35	Purchase of Power at Dam Site.	Enfield	Swift	New England Power Co.	Date of Agreement = June 2, 1932			Agreed Rates	19,367.18	June 1, 1935
36	Core Wall to Bed Rock at Dike Site.	Enfield & Ware	Swift	West Construction Co.	Dec. 9, 1932	25	Dec. 28, 1932	999,265.00	1,151,602.49	Dec. 22, 1934
39	Construction of Trunk Sewer.	Rutland & Holden	Ware	James J. Coughlan & Sons, Inc.	July 7, 1933	21	July 11, 1933	184,327.50	238,708.67	June 4, 1935
41	Construction of Portion of Belchertown-Pelham Highway.	Belchertown & Pelham	Swift	Carlo Bianchi & Company, Inc.	July 18, 1933	14	July 19, 1933	222,335.50	248,578.14 **	Nov. 20, 1934
44	Construction of Extension of Belchertown-Pelham Highway. North of New Salem Center.	New Salem & Orange	Swift	John Iafolla Construction Co.	Nov. 10, 1933	9	Nov. 14, 1933	179,480.50	199,940.12 **	Nov. 20, 1934

STATUS OF CONTRACTS IN FORCE ON NOV. 30, 1935

CONT. NO.	DESCRIPTION	LOCATION	SUPPLY	CONTRACTOR	BIDS OPENED	NO. OF BIDS	CONTRACT AWARDED	BASIS OF AWARD	PAYMENTS TO DATE
33	Purchase of Power at Shaft 1.	West Boylston	Ware	New England Power Co.	Date of Agreement = Aug. 6, 1931.			Agreed Rates	$ 1,923.63
38	Core Wall to Bed Rock at Dam Site.	Belchertown, Enfield & Ware	Swift	The Two Companies, Inc.	May 7, 1935	9	May 9, 1935.	$1,330,765.00	1,021,829.00
42	Use of Worcester Sewerage System and Treatment Works % Rutland-Holden Sewer.	Worcester	Ware	City of Worcester	Date of Agreement = May 1, 1933			Lump Sum = 325,000.00 Annual Charge = *	325,000.00 None
43	Construction of Extension of Belchertown-Pelham Highway to New Salem Center.	Shutesbury & New Salem	Swift	V. Barletta Co.	Aug. 11, 1933	7	Aug. 22, 1933	300,397.50	376,964.65 **
46	Connection with Rutland-Holden Sewer, & Disposal of Sewage from the U.S. Veterans Hospital.	Rutland (Note:- Payments under Contract 46 are RECEIVED by the M.D.W.S.C.)	Ware	U.S. Veterans Administration.	Date of Agreement = Nov. 7, 1934			Lump Sum = 37,000.00 Annual Charge = *	37,000.00 None
48	Connection with Rutland-Holden Sewer, & Disposal of Sewage from the Rutland State Sanatorium.	Rutland (Note:- Payments under Contract 48 are RECEIVED by the M.D.W.S.C.)	Ware	Rutland State Sanatorium.	Date of Agreement = June 5, 1934			Lump Sum = 60,000.00 Contingent Charge = *	60,000.00 None
49	Excavating Diversion Channels at the Site of Quabbin Reservoir.	Dana, Hardwick & Greenwich.	Swift	Cenedella & Co.	Sept. 10, 1935	12	Oct. 1, 1935	79,050.00	7,300.00
50	Dike Embankment - Quabbin Reservoir.	Enfield & Ware	Swift	The Arthur A. Johnson Corporation	Nov. 13, 1934	6	Nov. 26, 1934	1,446,655.00	400,643.00

* Proportion of Annual Maintenance Cost.

** Of these amounts the State Dept. of Public Works has paid $118,486.97 on Cont. 41, $101,705.13 on Cont. 43 and $63,222.73 on Cont. 44, covering the surfacing, guard rail and traffic signal duct items.

The above contracts were all awarded to the lowest bidder except Contract 43 which was awarded to the 2nd lowest bidder.

Commonwealth of Massachusetts
METR. DISTR. WATER SUPPLY COMMISSION

CANVASS OF BIDS FOR CONTRACT 38

OPENED MAY 7, 1935

FOR CONSTRUCTING A CORE WALL TO SOUND ROCK AT THE SITE OF THE MAIN DAM OF QUABBIN RESERVOIR IN THE TOWNS OF BELCHERTOWN, ENFIELD AND WARE

Item	Description	Unit	Quantity	* ① THE TWO COMPANIES C. J. MANEY COMPANY, INC. 50 CONGRESS ST. BOSTON, MASS. B. PERINI & SONS, INC. FRAMINGHAM, MASS.		② THE DOMINION CONSTRUCTION COMPANY, INC. ℅ JAMES J. COUGHLAN & SONS, INC. 80 FEDERAL ST. BOSTON, MASS.		③ CORNELL CONTRACTING CORPORATION 405 LEXINGTON AVE. NEW YORK, N. Y.		④ WEST CONSTRUCTION COMPANY 60 STATE ST. BOSTON, MASS.		⑤ RODGERS & HAGERTY INC. 500 5TH AVENUE NEW YORK, N. Y.		⑥ UNDERPINNING & FOUNDATION CO. INC. 155 EAST 44TH ST. NEW YORK, N. Y.		⑦ THE DRAVO CONTRACTING COMPANY NEVILLE ISLAND STA. PITTSBURGH, PA.		⑧ THE ARTHUR A. JOHNSON CORPORATION ENFIELD, MASS.		⑨ PETER F. CONNOLLY COMPANY 29-28 41ST AVENUE LONG ISLAND CITY, N. Y.	
				PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT
1	Clearing and grubbing	Acre	25	75.00	$ 1,875.00	90.00	$ 2,250.00	250.00	$ 6,250.00	102.00	$ 2,550.00	230.00	$ 5,750.00	100.00	$ 2,500.00	100.00	$ 2,500.00	75.00	$ 1,875.00	210.00	$ 5,250.00
2	Earth excavation in open cut	Cu. Yd.	230,000	.65	149,500.	.26	59,800.	.23	52,900.	.24	55,200.	.35	80,500.	.60	138,000.	.20	46,000.	.40	92,000.	.40	92,000.
3	Rock excavation as boulders in open cut	Cu. Yd.	7,000	.65	4,550.	.55	3,850.	.23	1,610.	.65	4,550.	.35	2,450.	1.	7,000.	.60	4,200.	2.	14,000.	2.50	17,500.
4	Rock excavation as ledge in open cut	Cu. Yd.	6,000	7.50	45,000.	6.	36,000.	3.50	21,000.	5.	30,000.	8.	48,000.	3.	18,000.	6.	36,000.	2.50	15,000.	4.	24,000.
5	Stripping	Cu. Yd.	60,000	.65	39,000.	.28	16,800.	.40	24,000.	.27	16,200.	.35	21,000.	.70	42,000.	.25	15,000.	.64	38,400.	.40	24,000.
6	Unconsolidated embankment	Cu. Yd.	40,000	.05	2,000.	.15	6,000.	.10	4,000.	.11	4,400.	.10	4,000.	.20	8,000.	.10	4,000.	.40	16,000.	.30	12,000.
7	Consolidated pervious embankment	Cu. Yd.	190,000	.05	9,500.	.09	17,100.	.12	22,800.	.11	20,900.	.15	28,500.	.30	57,000.	.11	20,900.	.46	87,400.	.50	95,000.
8	Rolled impervious embankment in core	Cu. Yd.	90,000	.60	54,000.	.60	54,000.	.40	36,000.	.63	56,700.	.45	40,500.	.30	27,000.	.60	54,000.	.50	45,000.	.40	36,000.
9	Rolled impervious embankment not in core	Cu. Yd.	40,000	.60	24,000.	.60	24,000.	.35	14,000.	.63	25,200.	.60	24,000.	.30	12,000.	.60	24,000.	.50	20,000.	.40	16,000.
10	Stone fills	Cu. Yd.	65,000	1.00	65,000.	.77	50,050.	.40	26,000.	.81	52,650.	.90	58,500.	.90	58,500.	.70	45,500.	.50	32,500.	1.	65,000.
11	Pumping (Unit price fixed)	Mil. ft.-gals.	300,000	.10	30,000.	.10	30,000.	.10	30,000.	.10	30,000.	.10	30,000.	.10	30,000.	.10	30,000.	.10	30,000.	.10	30,000.
12	Control of surface waters	Lump Sum		4,600.	4,600.	10,000.	10,000.	20,000.	20,000.	7,200.	7,200.	8,000.	8,000.	2,000.	2,000.	6,000.	6,000.	6,000.	6,000.	10,000.	10,000.
13	Earth excav. core wall, bottom open cut to Elev. 300	Cu. Yd.	35,000	7.	245,000.	7.	245,000.	12.	420,000.	6.15	215,250.	10.	350,000.	8.	280,000.	6,50	227,500.	12.50	437,500.	11.38	398,300.
14	Earth excavation for core wall, below Elev. 300	Cu. Yd.	5,000	7.	35,000.	15.10	75,500.	12.	60,000.	18.63	93,150.	10.	50,000.	10.	50,000.	9.	45,000.	12.50	62,500.	21.	105,000.
15	Rock excavation in caissons above Elev. 300	Cu. Yd.	3,000	11.	33,000.	9.50	28,500.	12.	36,000.	19.22	57,660.	20.	60,000.	8.	24,000.	11.	33,000.	20.25	60,750.	12.	36,000.
16	Rock excavation in caissons below Elev. 300	Cu. Yd.	1,000	11.	11,000.	20.	20,000.	20.	20,000.	30.26	30,260.	20.	20,000.	8.	8,000.	11.	11,000.	20.25	20,250.	21.	21,000.
17	Rock excav. core wall, below open cut, outside caisson limits	Cu. Yd.	300	10.	3,000.	10.	3,000.	12.	3,600.	6.48	1,944.	9.	2,700.	8.	2,400.	12.	3,600.	2.55	765.	12.50	3,750.
18	Preparing rock surface in caissons above Elev. 300	Sq. Yd.	1,100	2.	2,200.	9.	9,900.	3.	3,300.	9.37	10,307.	2.50	2,750.	8.	8,800.	3.	3,300.	9.	9,900.	5.	5,500.
19	Preparing rock surface in caissons below Elev. 300	Sq. Yd.	650	2.	1,300.	9.	5,850.	3.	1,950.	14.20	9,230.	2.50	1,625.	8.	5,200.	4.	2,600.	9.	5,850.	5.	3,250.
20	Preparing rock surface outside caisson limits	Sq. Yd.	600	2.	1,200.	4.	2,400.	3.	1,800.	3.20	1,920.	2.50	1,500.	8.	4800.	6.	3,600.	4.85	2,910.	5.	3,000.
21	Concrete, not placed under air pressure	Cu. Yd.	50,000	6.	300,000.	7.40	370,000.	6.	300,000.	7.68	384,000.	8.	400,000.	8.	400,000.	13.	650,000.	7.50	375,000.	8.	400,000.
22	Concrete, placed under air pressure	Cu. Yd.	7,000	6.	42,000.	6.70	46,900.	6.	42,000.	7.	49,000.	6.	42,000.	8.	56,000.	15.	105,000.	9.50	66,500.	8.	56,000.
23	Impervious filling in caissons	Cu. Yd.	5,000	1.	5,000.	1.08	5,400.	.70	3,500.	1.32	6,600.	.70	3,500.	7.	35,000.	1.50	7,500.	.62	3,100.	1.50	7,500.
24	Imper. fill. core wall, below open cut, outside caisson limits	Cu. Yd.	300	1.	300.	.68	204.	.70	210.	.85	255.	.70	210.	7.	2,100.	3.	900.	.62	186.	1.50	450.
25	Drilling holes in rock or masonry	Lin. ft.	12,000	.80	9,600.	1.40	16,800.	1.	12,000.	2.63	31,560.	1.	12,000.	2.	24,000.	1.	12,000.	.60	7,200.	1.25	15,000.
26	Furnishing and placing grout	Cu. Yd.	1,000	11.	11,000.	15.	15,000.	8.	8,000.	7.78	7,780.	16.	16,000.	15.	15,000.	15.	15,000.	6.25	6,250.	12.	12,000.
27	Portland cement	Barrel	90,000	2.20	198,000.	2.70	243,000.	3.	270,000.	3.03	272,700.	2.90	261,000.	3.	270,000.	2.30	207,000.	2.65	238,500.	2.75	247,500.
28	Maintenance of Highway	Lump Sum		2,000.	2,000.	2,500.	2,500.	10,000.	10,000.	5,600.00	5,600.	3,500.	3,500.	3,000.	3,000.	2,500.	2,500.	1,750.	1,750.	3,000.	3,000.
29	Maintenance of Engineer's office	Month	19	60.	1,140.	200.	3,800.	250.	4,750.	150.00	2,850.	200.	3,800.	200.	3,800.	200.	3,800.	135.	2,565.	3,800.	72,200.
30	Cleaning up	Lump Sum		1,000.	1,000.	2,500.	2,500.	6,000.	6,000.	2,000.	2,000.	1,000.	1,000.	2,000.	2,000.	2,000.	2,000.	2,500.	2,500.	2,000.	2,000.
			Totals		$1,330,765.00		$1,406,104.00		$1,461,670.00		$1,487,616.00		$1,582,785.00		$1,596,100.00		$1,623,400.00		$1,702,151.00		$1,818,200.00

*Contract awarded May 9, 1935
Contract executed May 15, 1935

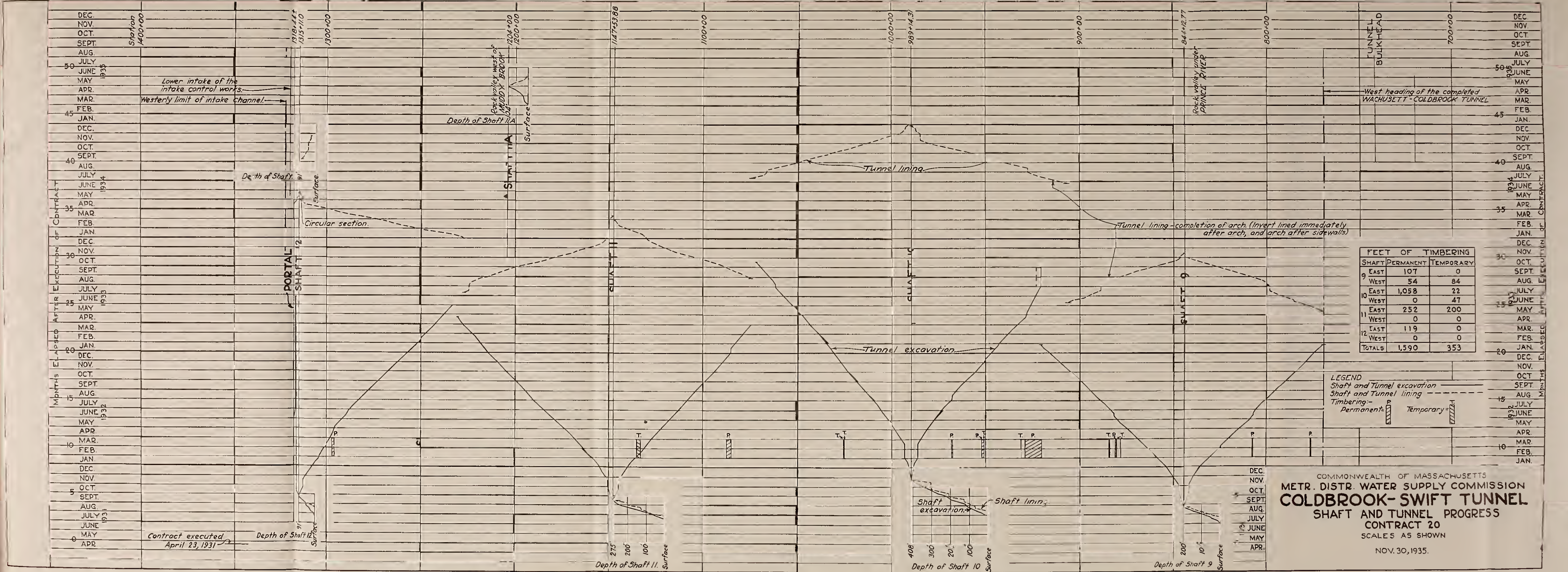
CANVASS OF BIDS FOR CONTRACT 49, OPENED SEPT. 10, 1935

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
CONTRACT 49
FOR EXCAVATING DIVERSION CHANNELS AT THE SITE OF QUABBIN RESERVOIR IN THE TOWNS OF DANA, HARDWICK, AND GREENWICH

ITEM	DESCRIPTION OF ITEM	UNIT	QUANTITY	① CENEDELLA & CO. ★ 167 MAIN ST, MILFORD, MASS.		② EDWARD J. BYRNE 89 STATE ST, BOSTON, MASS.		③ V. BARLETTA CO. 8 WHIPPLE AVE, ROSLINDALE, MASS.		④ CARLO BIANCHI & COMPANY, INC. FRAMINGHAM, MASS.		⑤ KELLEHER CORPORATION TURNERS FALLS, MASS.		⑥ RALPH D. MAROIS 18 ARTHUR ST, WORCESTER, MASS.	
				PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT
1	*Clearing.*	*Acre*	*100*	*50.00*	*5,000.00*	*100.00*	*10,000.00*	*95.00*	*9,500.00*	*70.00*	*7,000.00*	*125.00*	*12,500.00*	*150.00*	*15,000.00*
2	*Grubbing.*	*Acre*	*50*	*50.00*	*2,500.*	*100.00*	*5,000.*	*350.00*	*17,500.*	*200.00*	*10,000.*	*450.00*	*22,500.*	*150.00*	*7,500.*
3	*Earth excavation in channel between middle and east branches.*	*Cu. Yd.*	*220,000*	*.26*	*57,200.*	*.27*	*59,400.*	*.23*	*50,600.*	*.25*	*55,000.*	*.22*	*48,400.*	*.25*	*55,000.*
4	*Earth excavation in channel at Shaft 11-A.*	*Cu. Yd.*	*4,500*	*1.00*	*4,500.*	*.80*	*3,600.*	*.50*	*2,250.*	*1.20*	*5,400.*	*1.25*	*5,625.*	*.80*	*3,600.*
5	*Earth excavation in channel at Shaft 12.*	*Cu. Yd.*	*13,000*	*.26*	*3,380.*	*.79*	*10,270.*	*.35*	*4,550.*	*.50*	*6,500.*	*.30*	*3,900.*	*1.00*	*13,000.*
6	*Excavation of boulders.*	*Cu. Yd.*	*10,000*	*.01*	*100.*	*.01*	*100.*	*.75*	*7,500.*	*.75*	*7,500.*	*.60*	*6,000.*	*.60*	*6,000.*
7	*Grading banks of lower intake channel at Shaft 12.*	*Cu. Yd.*	*500*	*1.00*	*500.*	*1.00*	*500.*	*.75*	*375.*	*1.00*	*500.*	*1.00*	*500.*	*1.00*	*500.*
8	*Gravel road surfacing.*	*Cu. Yd.*	*1,600*	*.65*	*1,040.*	*.40*	*640.*	*.50*	*800.*	*.75*	*1,200.*	*.80*	*1,280.*	*.75*	*1,200.*
9	*Bituminous material.*	*Gallon*	*1,200*	*.15*	*180.*	*.15*	*180.*	*.15*	*180.*	*.25*	*300.*	*.20*	*240*	*.20*	*240.*
10	*Corrugated iron culvert pipe.*	*Pound*	*2,000*	*.15*	*300.*	*.11*	*220.*	*.10*	*200.*	*.15*	*300.*	*.10*	*200*	*.20*	*400.*
11	*Paving.*	*Cu. Yd.*	*170*	*5.00*	*850.*	*5.00*	*850.*	*3.00*	*510.*	*7.00*	*1,190.*	*5.00*	*850*	*7.00*	*1,190.*
12	*Wooden guard rail.*	*Lin. Ft.*	*2,000*	*.55*	*1,100.*	*.60*	*1,200.*	*.35*	*700.*	*.45*	*900.*	*.60*	*1,200*	*.50*	*1,000.*
13	*Highway bridge.*	*M. Ft. B. M.*	*30*	*80.00*	*2,400.*	*125.00*	*3,750.*	*100.00*	*3,000.*	*100.00*	*3,000.*	*100.00*	*3,000*	*85.00*	*2,550.*
			TOTALS →		*$79,050.00*		*$95,710.00*		*$97,665.00*		*$98,790.00*		*$106,195.00*		*$107,180.00*

ITEM	DESCRIPTION OF ITEM	UNIT	QUANTITY	⑦ JOHN IAFOLLA CONSTRUCTION CO. 11 VAN BRUNT AVE, DEDHAM, MASS.		⑧ S. J. GROVES AND SONS CO. 509 WESLEY TEMPLE BLDG, MINNEAPOLIS MINN.		⑨ PETER SALVUCCI 55 POND ST, WALTHAM, MASS.		⑩ H. E. CLINE CONSTRUCTION CO. 1 BEACON ST, BOSTON, MASS.		⑪ J. H. FERGUSON CO. 289 CHAPMAN ST, PROVIDENCE, R. I.		⑫ THE TWO COMPANIES INC. ENFIELD, MASS.	
				PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT	PRICE	AMOUNT
1	*Clearing.*	*Acre*	*100*	*200.00*	*20,000.00*	*150.00*	*15,000.00*	*100.00*	*10,000.00*	*200.00*	*20,000.00*	*150.00*	*15,000.00*	*150.00*	*15,000.00*
2	*Grubbing.*	*Acre*	*50*	*400.00*	*20,000.*	*250.00*	*12,500.*	*300.00*	*15,000.*	*50.00*	*2,500.*	*200.00*	*10,000.*	*150.00*	*7,500.*
3	*Earth excavation in channel between middle and east branches.*	*Cu. Yd.*	*220,000*	*.24*	*52,800.*	*.30*	*66,000.*	*.35*	*77,000.*	*.35*	*77,000.*	*.39*	*85,800.*	*.70*	*154,000.*
4	*Earth excavation in channel at Shaft 11-A.*	*Cu. Yd.*	*4,500*	*1.00*	*4,500.*	*1.75*	*7,875.*	*1.00*	*4,500.*	*1.00*	*4,500.*	*1.20*	*5,400.*	*.95*	*4,275.*
5	*Earth excavation in channel at Shaft 12.*	*Cu. Yd.*	*13,000*	*.50*	*6,500.*	*.55*	*7,150.*	*.50*	*6,500.*	*.80*	*10,400.*	*.60*	*7,800.*	*.90*	*11,700.*
6	*Excavation of boulders.*	*Cu. Yd.*	*10,000*	*.24*	*2,400.*	*1.00*	*10,000.*	*1.00*	*10,000.*	*2.00*	*20,000.*	*2.00*	*20,000.*	*.70*	*7,000.*
7	*Grading banks of lower intake channel at Shaft 12.*	*Cu. Yd.*	*500*	*.50*	*250.*	*1.00*	*500.*	*.30*	*150.*	*.80*	*400.*	*1.50*	*750.*	*1.50*	*750.*
8	*Gravel road surfacing.*	*Cu. Yd.*	*1,600*	*.50*	*800.*	*1.25*	*2,000.*	*.50*	*800.*	*3.00*	*4,800.*	*1.80*	*2,880.*	*.65*	*1,040.*
9	*Bituminous material.*	*Gallon*	*1,200*	*.13*	*156.*	*.50*	*600.*	*.20*	*240.*	*.15*	*180.*	*.15*	*180.*	*.15*	*180.*
10	*Corrugated iron culvert pipe.*	*Pound*	*2,000*	*.12*	*240.*	*.12*	*240.*	*.15*	*300.*	*.15*	*300.*	*.20*	*400.*	*.13*	*260.*
11	*Paving.*	*Cu. Yd.*	*170*	*4.00*	*680.*	*5.00*	*850.*	*3.00*	*510.*	*14.00*	*2,380.*	*5.00*	*850.*	*5.00*	*850.*
12	*Wooden guard rail.*	*Lin. Ft.*	*2,000*	*.35*	*700.*	*.75*	*1,500.*	*.60*	*1,200.*	*1.50*	*3,000.*	*.50*	*1,000.*	*.65*	*1,300.*
13	*Highway bridge.*	*M. Ft. B. M.*	*30*	*70.00*	*2,100.*	*1.00*	*3,000.*	*100.00*	*3,000.*	*150.00*	*4,500.*	*100.00*	*3,000.*	*110.00*	*3,300.*
			TOTALS →		*$111,126.00*		*$127,215.00*		*$129,200.00*		*$149,960.00*		*$153,060.00*		*$207,155.00*

★ *Contract awarded October 1, 1935*
Contract executed October 2, 1935



COMMONWEALTH OF MASSACHUSETTS

METR. DISTR. WATER SUPPLY COMMISSION

COLDBROOK-SWIFT TUNNEL

SHAFT AND TUNNEL PROGRESS

CONTRACT 20

SCALES AS SHOWN

NOV. 30, 1935.

FEET OF TIMBERING			
SHAFT		PERMANENT	TEMPORARY
9	EAST	107	0
	WEST	54	84
10	EAST	1,058	22
	WEST	0	47
11	EAST	252	200
	WEST	0	0
12	EAST	119	0
	WEST	0	0
TOTALS		1,590	353

LEGEND
Shaft and Tunnel excavation ———
Shaft and Tunnel lining - - - - -
Timbering:-
Permanent = ▨ Temporary = ▨

MONTHLY RAINFALL IN INCHES AT STATIONS ON THE WARE AND SWIFT WATERSHEDS, 1935

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
WARE WATERSHED													
Ware River Intake Works*	4.72	2.99	2.22	2.74	3.08	5.40	3.74	1.10	4.53	1.11	2.70	1.32	35.65
West Rutland*	5.14	3.22	2.61	2.93	3.29	5.73	3.85	1.25	4.55	1.21	3.55	1.41	38.74
North Rutland	7.54	4.22	2.09	3.85	2.80	7.08	3.63	.98	5.71	1.00	4.28	1.59	44.77
Williamsville	5.31	2.71	2.74	3.45	3.02	6.06	2.92	1.07	4.63	1.41	3.47	.87	37.66
Hubbardston	4.15	2.54	1.85	2.54	3.16	6.87	3.62	1.09	4.58	1.33	4.68	1.02	37.43
1935 Mean	5.37	3.14	2.30	3.10	3.07	6.23	3.55	1.10	4.80	1.21	3.74	1.24	38.85
12-year Mean	3.17	2.88	3.36	3.49	3.16	3.69	4.15	3.87	4.72	3.31	3.43	2.78	42.01
SWIFT WATERSHED													
West Ware	4.44	2.94	1.83	3.03	1.81	5.24	2.61	.92	4.57	1.60	3.75	1.09	33.83
Enfield	5.40	3.72	2.07	3.76	2.63	5.65	2.42	.74	5.17	1.27	4.10	1.22	38.15
Greenwich	5.05	2.32	1.85	2.56	2.54	5.82	3.61	.73	4.63	1.42	3.89	.89	35.31
North Dana	5.77	3.06	1.93	3.45	3.80	5.82	2.83	1.27	5.18	1.51	4.24	.71	39.57
Dana	4.49	2.14	2.13	3.74	3.38	4.83	3.49	1.13	3.45	1.62	4.21	.89	35.50
Packardsville	4.14	2.43	1.84	2.79	2.60	6.18	2.89	.94	5.33	1.50	4.36	1.03	36.03
Prescott	4.40	2.53	1.62	3.13	2.47	5.92	2.46	1.08	5.22	1.18	4.18	.81	35.00
Shutesbury	5.71	3.08	1.83	3.27	2.68	5.80	4.18	1.30	5.82	1.36	4.75	1.19	40.97
New Salem	5.55	2.73	1.43	2.59	3.00	5.87	3.05	1.16	4.92	1.26	4.72	1.02	37.30
Wendell	4.34	2.55	1.62	3.11	3.11	6.28	2.29	.88	4.83	1.62	4.69	1.93	37.25
Petersham**	7.09	3.43	2.23	4.12	2.32	5.64	2.08	1.49	4.70	1.11	5.04	1.04	40.29
1935 Mean	5.12	2.81	1.85	3.23	2.76	5.73	2.90	1.06	4.89	1.40	4.36	1.07	37.18
16-year Mean	3.25	2.98	3.35	4.11	3.47	4.65	4.16	4.09	4.50	3.14	4.12	3.13	44.95

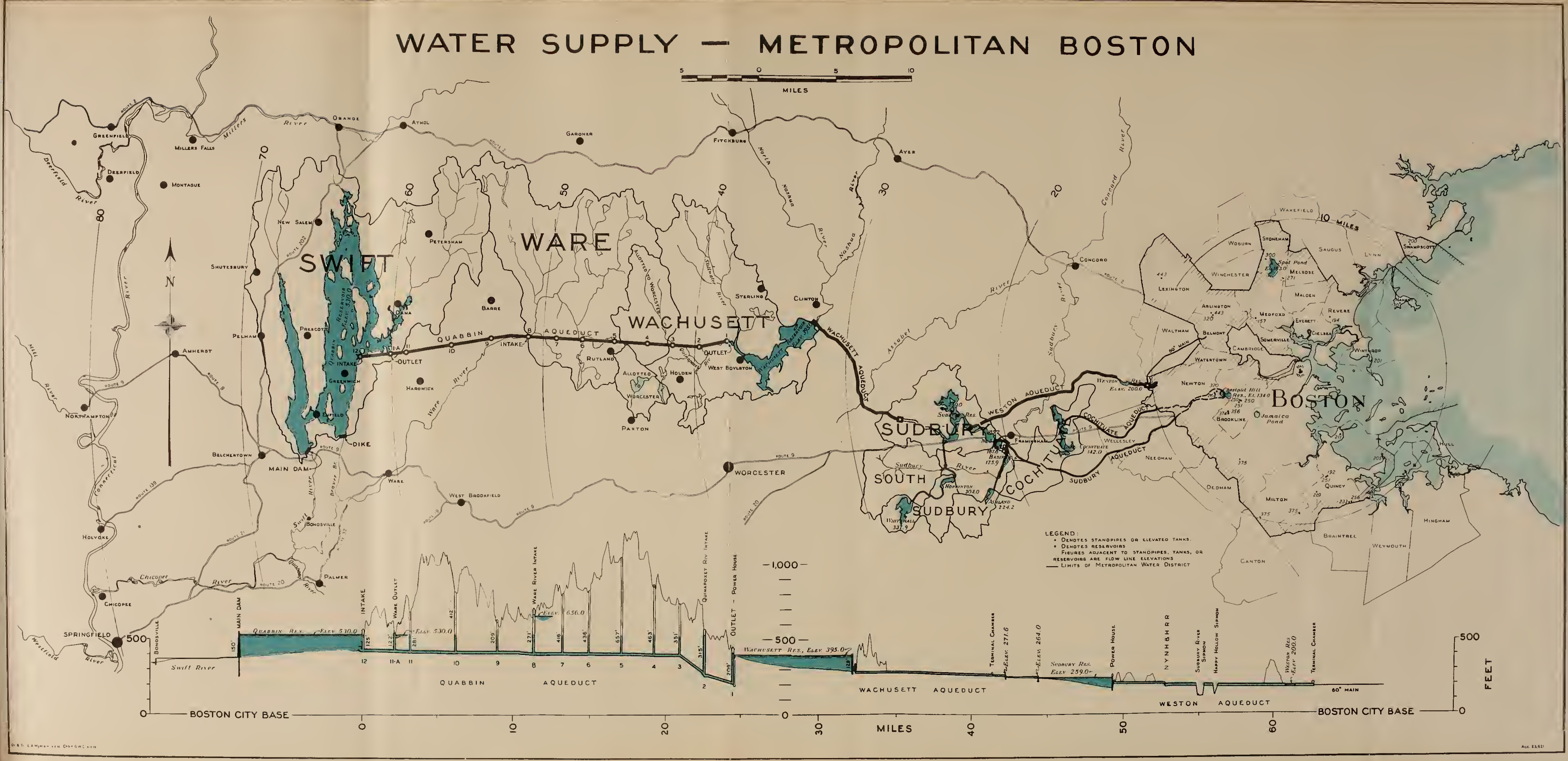
* Station maintained by Metropolitan District Water Supply Commission.

** Station maintained by Metropolitan District Commission.

Data for all other stations obtained through courtesy of State Department of Public Health.

SUMMARY OF MONTHLY RAINFALL IN INCHES ON THE WARE AND SWIFT WATERSHEDS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
					WARE WATERSHED								
1924	3.63	2.00	2.10	5.66	2.89	1.14	2.77	4.89	5.05	.07	3.38	2.10	35.68
1925	2.54	2.23	5.00	2.86	2.27	4.29	4.94	1.86	5.16	4.54	3.40	2.72	41.81
1926	2.42	4.06	2.80	2.35	2.18	2.72	2.67	2.81	1.46	5.25	5.63	3.29	37.64
1927	2.61	3.34	1.54	2.12	3.94	2.62	7.32	6.95	3.39	4.76	6.97	5.91	51.47
1928	2.49	3.16	1.77	4.59	2.77	6.79	5.98	5.96	3.29	1.69	2.04	1.49	42.02
1929	4.19	3.04	3.31	5.44	4.52	3.08	.99	1.71	2.60	2.24	2.97	2.68	36.77
1930	2.08	1.99	3.03	1.63	2.82	3.42	7.19	1.50	2.33	2.63	2.85	1.57	33.04
1931	2.40	2.44	5.12	2.91	5.15	4.68	3.50	7.61	2.25	2.97	1.39	3.34	43.76
1932	4.65	1.96	5.11	1.77	1.56	1.63	4.41	4.24	6.48	6.59	4.34	1.97	44.71
1933	2.28	3.87	5.31	5.47	2.59	2.24	2.89	5.10	10.17	4.99	1.34	2.87	49.12
1934	3.37	3.32	2.94	4.02	4.23	5.42	3.64	2.66	9.63	2.73	3.12	4.20	49.28
1935	5.37	3.14	2.30	3.10	3.07	6.23	3.55	1.10	4.80	1.21	3.74	1.24	38.85
Mean	3.17	2.88	3.36	3.49	3.16	3.69	4.15	3.87	4.72	3.31	3.43	2.78	42.01
					SWIFT WATERSHED								
1920	2.21	4.88	3.18	6.10	3.45	5.96	3.31	5.17	6.92	1.17	5.81	6.36	54.52
1921	2.42	2.65	3.69	8.61	3.32	4.33	6.47	3.70	2.71	2.27	6.52	2.49	49.18
1922	1.55	3.00	5.52	2.06	4.69	11.83	5.34	4.37	2.80	3.42	1.82	3.43	49.83
1923	6.55	1.90	2.57	4.66	2.31	3.40	2.44	3.51	2.04	5.53	5.29	4.69	44.89
1924	4.18	2.10	1.34	5.41	3.37	1.72	2.48	3.56	5.23	.06	2.98	2.16	34.59
1925	2.53	3.42	4.76	3.12	2.64	4.41	6.39	1.98	4.22	4.51	3.52	2.67	44.17
1926	2.73	4.12	3.26	2.58	1.80	3.23	3.41	3.63	1.50	5.66	6.17	2.94	41.03
1927	2.48	3.46	1.59	1.97	4.85	3.79	6.93	6.58	2.94	4.65	8.23	5.72	53.19
1928	2.56	3.10	2.21	4.93	2.79	7.22	6.20	7.65	3.75	1.61	2.30	1.25	45.57
1929	4.48	3.36	3.28	6.37	4.51	3.29	.99	1.65	4.55	2.57	3.12	3.66	41.82
1930	2.17	1.90	3.45	1.21	3.65	3.98	5.53	1.76	2.86	2.35	3.57	1.53	33.97
1931	2.91	1.81	4.07	2.90	6.51	4.64	3.04	6.62	2.38	3.34	1.57	3.73	43.53
1932	4.37	2.45	4.27	2.49	1.90	2.51	5.25	4.04	5.24	4.27	4.75	1.96	43.49
1933	2.33	3.66	5.04	6.13	2.33	2.86	2.45	6.94	10.32	4.69	1.43	3.42	51.60
1934	3.42	3.11	3.52	4.03	4.58	5.44	3.45	3.21	9.71	2.82	4.44	2.96	50.69
1935	5.12	2.81	1.85	3.23	2.76	5.73	2.90	1.06	4.89	1.40	4.36	1.07	37.18
Mean	3.25	2.98	3.35	4.11	3.47	4.65	4.16	4.09	4.50	3.14	4.12	3.13	44.95



WATER SUPPLY — METROPOLITAN BOSTON

3m-6-'36. No. 8034.

APPENDIX TO REPORT OF CHIEF ENGINEER

GEOLOGY OF REGION IN WHICH QUABBIN AQUEDUCT AND QUABBIN RESERVOIR ARE LOCATED

Chapter 321, Acts of 1927, provides that "The Commission shall collect and publish in its reports such information as to the geology of the region in which any of the works which it is authorized to construct may be located as may be of value in connection with the geological history of the State."

The geological work has been done by Frank E. Fahlquist, Senior Civil Engineer, in consultation with Charles P. Berkey, Consulting Geologist, and the following report summarizes previous geological information contained in Annual Reports of 1927, 1928 and 1929, and covers also such additional geological information as has been gained up to date.

CONTENTS

Page

INTRODUCTION 5
Geological problems of tunnel location.

GENERAL GEOLOGIC SETTING 7
Ancient, Pre-Glacial or Tertiary drainage courses. Glacial drift deposits. Investigations in the valleys.

SPECIFIC GEOLOGICAL INVESTIGATIONS 10
Quinapoxet Valley. Ware-Prince Valleys. Portal site. Muddy Brook Valley.

THE ROCK FLOOR 12
Record of geologic features of the tunnel. Geologic interpretation. Rock formations. The mixed or hybrid rocks. Granitization of schist bodies. Structural features. Thickness of formations. Folds and faults. Age and formational relations.

RELATION OF CONSTRUCTION TO GEOLOGIC CONDITIONS 33
Scaling of hard rock. Timbering of soft rock. Ground water circulation. Hardness of formations. Methods of tunnel excavation. Drilling. Mucking. Rock breakage. Tunnel rocks as aggregates in concrete lining.

GEOLOGY OF MAIN DAM AND BEAVER BROOK DIKE 39
Origin of the Swift River Valley. Detailed investigations. Glacial deposits of Beaver Brook and Swift River valleys. Materials for construction. Cross section. Rock formation of the valley floor.

GEOLOGICAL STUDIES RELATED TO HIGHWAYS 44
Highway locations. Foundation materials.

SUMMARY 45

INTRODUCTION

The extension of the water supply system of the Boston Metropolitan District to the Ware and Swift rivers involved the construction of the Quabbin Aqueduct, a tunnel in solid rock 25 miles in length, extending westerly from Wachusett Reservoir to the valley of the Swift River where the Quabbin Reservoir will be built. The present system as well as the additions thereto are shown on the map entitled "Water Supply—Metropolitan Boston." The portion of Quabbin Aqueduct from Wachusett Reservoir to the Ware River, about 13 miles in length, was practically completed in March, 1931, and water of the Ware River then diverted to the Wachusett Reservoir. The extension of Quabbin Aqueduct to the Swift River at Quabbin Reservoir was begun in 1931 and practically completed in the fall of 1935.

The Quabbin Reservoir requires two dams, one across the Swift River Valley, known as the Main Dam, and the other across the valley of Beaver Brook, known as the Dike. At the Main Dam a stream control diversion tunnel was constructed in rock at the westerly end of the dam, and at both the Main Dam and the Dike concrete cut-off walls to rock, formed by a succession of concrete caissons sunk through thick glacial overburden, have been completed. The work of constructing the embankment above the caissons at the Dike is under way and a similar contract is being prepared for the embankment at the Main Dam.

GEOLOGICAL PROBLEMS

The geological problems confronted in locating the tunnel sufficiently deep in bed rock to lie beneath surficial weaknesses and buried gorges involved the following features: the location and depth of old stream channels; determination of the kinds and character of the rocks through which the tunnel passes and their behavior during and after construction; the possibility of utilizing rock removed from the tunnel excavation for concrete aggregates; a proper distribution of shafts to secure the desired excavation progress, located at low points in the topography where deep excavations through earth would be avoided; the position and character of the weak spots and their estimated effect upon the feasibility of the tunnel construction; the probable effect upon ground water circulation and estimated leakage into the tunnel.

The problems at the Main Dam and Dike involved chiefly the character of the rock and the material overlying it at the sites of these structures and the location in the vicinity of material of suitable character for building the embankments.

The necessary preliminary investigations to determine suitable locations of structures and the construction of these works have contributed substantially to an understanding of the geology of the region. Investigations were made to determine the following: grouping of the several rock types into formational units; determination of the character and thickness of the schist rocks, the banded rocks or gneisses and of the original sediments from which the schists and the gneisses were largely derived; determination of the structural relation of the schists and gneisses of the district one to another and also their relation to the Oakdale quartzite and the Worcester phyllite formations which are considered to be of Carboniferous age; determination of the mode of emplacement of the granite and the amount of replacement accomplished by the invasion of igneous material into the older metamorphic formations; determination of the influence of remnant schist masses engulfed in the granite; correlation of formations and their geologic age.

An important contribution to Massachusetts geology was made in 1917 by the United States Geological Survey in the report on "The Geology of Massachusetts and Rhode Island" by B. K. Emerson. This report contains the most complete information available regarding the rocks of the State, but in the opinion of some geologists it has raised certain questions regarding particularly the geologic structure of the formations, their geologic age and the correlation of formations of adjoining areas.

TUNNEL LOCATION

The earlier stages of geological investigation were concerned primarily with the location of the tunnel lines and the selection of suitable shaft sites. Of first concern was the thickness of glacial drift, the depth of pre-Glacial river channels and their bearing on the location of the tunnel grade.

The engineering requirements of the project placed the following limitations on the location of the shafts and tunnel:

1. The easterly terminus of the tunnel, Shaft 1 (See Plate 1), was limited to some point adjacent to Wachusett Reservoir; the westerly terminus, the portal at Shaft 12, was limited to a suitable point along the east side of the proposed Quabbin Reservoir.
2. An intake shaft, Shaft 8, the location of which was restricted not only by natural and engineering requirements but also by legal limitations, was to be constructed on the Ware River near Coldbrook.
3. The location of a shaft, Shaft 2, was selected near the junction of Trout Brook and the Quinapoxet River in order that the combined flows of these streams could, if desired, be diverted into the tunnel.
4. It was important to have the construction of the easterly section of the tunnel between Shafts 1 and 8 completed early in 1931 to permit the diversion of the Ware River flows. This portion of the tunnel, therefore, was designed to be excavated from eight shafts spaced as nearly at equal intervals as the topography would permit.
5. Fewer shafts were necessary for the westerly section, between Shaft 8 and the portal at Quabbin Lake, because more time was available for its construction. The westerly section was therefore laid out to be constructed from only four shafts or seven headings, Shaft 11–A being constructed only as a waterway shaft.

Quabbin Aqueduct as constructed extends from the northwest side of Wachusett Reservoir south of the village of Oakdale to a point near Quabbin Lake about one mile south of Greenwich Village. Excavation was carried through solid rock throughout the entire length of the tunnel, the amount of rock cover above the tunnel varying between 55 and 800 feet. In the easterly 3½ miles the tunnel invert lies between 200 and 385 feet above the Boston City Base.* At the portal the invert is at an elevation about 414 feet above Boston City Base.

The completed aqueduct will fulfill several functions: (a) it will furnish a means of bringing water from Quabbin Reservoir, which will have a maximum flow line elevation 530 feet above Boston City Base, to Wachusett Reservoir; (b) it will permit at Shaft 8, at an elevation 656 feet above Boston City Base, diversion by gravity of the flood flows of the Ware River into either Quabbin or Wachusett reservoirs; (c) it will permit at Shaft 2, at an elevation 540 feet above Boston City Base, diversion of flows of the Quinapoxet River to Quabbin Reservoir, if desired. The flow of water in the tunnel will be controlled by gates at the Wachusett Reservoir end. Water flowing west through the tunnel will normally enter Quabbin Reservoir through Shaft 11-A located about 2½ miles east of the portal. When the flow is to the east, water from Quabbin Reservoir will enter the tunnel through Shaft 12 and be discharged into Wachusett Reservoir through Shaft 1.

Quabbin Aqueduct is lined throughout with concrete, and, except for circular sections about 500 feet in length at the easterly end and 200 feet at the westerly end, is of horseshoe shape 12 feet 9 inches high by 11 feet wide with weep holes which prevent water pressure on the lining.

The circular sections are 12 feet 9 inches in diameter with the lining grouted against the rock to prevent leakage either into or out of the tunnel. After completion of Quabbin Reservoir the hydraulic grade of the tunnel will generally be 100 feet or more above the tunnel roof.

The construction shafts have an inside diameter of 14 feet and are lined with concrete which was placed as the shafts were excavated, to avoid the hazard of falling rock. This size of shaft was sufficient to allow the installation of double hoists for the removal of tunnel muck and provided space for water and compressed air pipes, electric wiring, ventilation pipes and emergency exit ladders. Ledge, except at Shaft 3, was from 3 feet to 34 feet below the surface. At Shaft 3 it was necessary to sink a concrete caisson through 61 feet of earth to reach bed rock.

---

* Approximately 6 feet below mean sea level as determined by the U. S. Coast and Geodetic Survey.

For shaft and tunnel excavation the contractors were paid at the contract unit prices for fixed volumes of excavation and fixed thicknesses of lining. A typical section of the tunnel is shown in Figure 1. The minimum thickness of lining was established for each cross section by a so-called "A" line beyond which no points of rock were allowed to project. In sound rock this was fixed at 3 inches on the side walls and invert and 8 inches on the arch. Except where permanent timber support was required the "B" line, which was generally the pay line for both excavation and concrete, was 12 inches from the "A" line on the side walls and arch and 2 inches on the invert. The "B" line was intended to represent a fair average of the irregular rock breakage, the actual average of which for the entire tunnel was about 10½ inches (See Plate 12). The normal volume of rock excavation in the tunnel was about 6.8 cubic yards per linear foot. Concrete lining averaged about 2.1 cubic yards per linear foot.

General Geologic Setting

The tunnel crosses a portion of the upland of central Massachusetts known geologically as the Worcester County plateau, a large part of which stands between 1,000 and 1,200 feet above sea level. Protruding above the general level of this area are isolated sections of considerably higher elevation called monadnocks, such as Mt. Wachusett, Elevation 2,000, and Asnebumskit Hill, Elevation 1,400. Geologic investigators[1] have previously noted the uniformity in the contour of the horizon line and have recognized in the general correspondence of the summits of the parallel ridges the former existence of a nearly uniform surface sloping gently toward the southeast with but few areas rising above it. Geologists have reasoned that in some past geological time this part of the state was eroded nearly to sea level, resulting in the formation of a plain, which has been designated as the Cretaceous peneplain from the geological period dating its development.

In general the hills and valleys are oriented in a north-south direction which is closely parallel to the folds in the geologic structure of the area. There are exceptions, however, which are sufficiently numerous to indicate that dissection or erosion of the ancient surface or peneplain was not controlled entirely by the distribution and structure of the underlying rock formations. An explanation of this has been advanced by Crosby[2] who believed that the peneplain at the time of its fullest development was covered by a thick mantle of sediments upon which a drainage pattern was developed without much regard for the structure of the underlying hard and soft rocks. At this stage of the erosional cycle the stream gradients were steepened and the rivers rejuvenated as the result of crustal disturbances. The rivers then became entrenched in the thick mantle of weathered rock and soil deposits. By the time these residual deposits were removed the streams had been superimposed on the older crystalline rock floor. The pattern of this ancient drainage system can be partly traced and reconstructed except in those areas where the valleys have been too deeply buried by glacial deposits.

As the ice sheet advanced during the succeeding epoch, known as the Glacial period, several of these valleys were slightly deepened and widened and the topography somewhat modified by ice erosion. As the glacier retreated large quantities of rock material which had been gathered by and frozen into the ice were deposited, in general, to rather shallow depths in the higher elevations but accumulated to considerable depths within the valleys. Since the Glacial period the regular surface geological processes have operated in a comparatively simple manner, the main feature being continued erosion of the glacial drift deposits.

---

[1] Alden, Wm. C., Physical Features of Central Massachusetts, United States Geological Survey, Bulletin 760, 1924, pp. 15–18.

[2] Crosby, W. O., Geological History of the Nashua Valley during the Tertiary and Quaternary Periods, Tech. Quart. Vol. 12, 1899, pp. 288–324.

Ancient, Pre-Glacial, or Tertiary Drainage Courses

Many of the streams of this section are too small to have excavated the broad and deep depressions which they now occupy. There are in the topography numerous notches or gaps cutting through rock divides which are now unoccupied by streams. These features, which are duplicated many times throughout New England and other sections of the country, have long been recognized by geologists as being related to the pre-historic river systems developed during a long period of erosion occurring before the Glacial period. The most important of these rivers are shown in Figure 2 and are summarized as follows:

1. *The Tertiary Stillwater River.* In the southern rim of the Nashua Valley at the head of Quinsigamond Valley there is a depression or gap one-half mile wide at an elevation about 440 feet above sea level. Three miles farther west and extending north from Oakdale is the valley of the Stillwater River. The normal course of that stream in early Tertiary times, before extension of the Nashua Valley westward, continued southerly through this gap into the Quinsigamond Valley and connected with the Blackstone Valley. There is also the possibility that before this time the Stillwater River flowed in a more southerly direction from the valley north of Oakdale through the valley of Malden Brook, leaving a gap near Summit at approximately 660 feet above sea level.

2. *The Tertiary Quinapoxet River.* The course of the tributaries of the Quinapoxet River suggests the earlier existence of two separate river systems. One course carried drainage from the southeast slopes of Mt. Wachusett by way of Governor and Trout Brook valleys, thence by way of the Quinapoxet River, Chaffin Pond and the gap at Elevation 760 south of Chaffin Pond into North Pond, to a larger valley at Worcester. The other, designated by Perry[1] as the "Auburn River," carried drainage from the south and southwest slopes of Mt. Wachusett by way of South Wachusett Brook and Cobb Brook valleys, Quinapoxet River Valley, Maple Spring and Eagleville Ponds, into Tatnuck Brook Valley; and is suggested by the gap at the head of Tatnuck Brook Valley at an elevation of about 820 feet above sea level. It seems probable that the "Auburn River" was first beheaded at a point in the vicinity of Quinapoxet Pond by a backward cutting tributary of the Quinapoxet, the course of which lies northwestward from Unionville. This suggestion appears reasonable in the light of information obtained later from the geologic section of the tunnel excavation which showed that a fault, striking in a northwesterly direction, coincides with the course of the valley.

3. *The Tertiary Nashua River.* During early Tertiary times, while the river systems noted above were eroding their valleys, the Tertiary Nashua River was rapidly cutting back (westward) over the softer micaceous schists underlying the main part of the valley floor. Crosby[2] has suggested that in one stroke the Stillwater-Quinapoxet system was diverted to the Nashua by the cutting away of the divide above Quinsigamond Valley, the component parts of the Quinapoxet having been previously captured by the Stillwater. The rock floor of the pass at the head of Quinsigamond Valley is at an elevation of about 440 feet above sea level, and that at the confluence of the Quinapoxet-Stillwater rivers is less than 375 feet above sea level.

4. *The Tertiary "Rutland" River.* A large part of the drainage from the western slopes of Mt. Wachusett was originally directed through the valley now occupied by the upper reaches of the Ware River, and through the valley now occupied by Long Meadow Brook, thence by way of Long Pond, Browning Pond, and Seven Mile River. Along this course there is a gap between Long and Browning ponds at an elevation of about 920 feet.

5. *The Tertiary Burnshirt River.* A southeasterly extension from Coldbrook of the Burnshirt and Ware River valleys is suggested by the topography, especially in the vicinity of Muddy Pond, situated at the head of the valley now occupied by Deans Reservoir, Brooks Pond and Five Mile River. That this course was identified with the earlier Tertiary history of the Ware River system is indicated by the gap south of Muddy Pond at an elevation of about 880 feet.

---

[1] Perry, J. H., The Physical Geography of Worcester, Mass., Worcester Natural History Society, 1898, p. 40.

[2] Op. cit.

6. The Tertiary Ware River. The Ware River Valley above Barre Plains becomes narrower and joins the valley of the Ware and Burnshirt rivers in the vicinity of Coldbrook. The smaller tributary, Prince River Valley, has special significance in that it probably was part of the earlier Tertiary Ware River Valley before the divide to the east had been eroded. These conclusions are more fully presented later in the discussion concerning interpretation of profiles obtained from borings.

7. The Tertiary Moose River. The presence of a gap at an elevation of about 770 feet between Mill and Winimusset brooks, and the position of the valleys occupied by these two brooks with respect to Moose and Pine Hill brooks, suggests two pre-Glacial stream possibilities, one of which, shown in Figure 2, indicates that Moose Brook Valley, although offset one mile farther west, had an erosional history in common with Mill and Winimusset Brook valleys. The other possibility is that the pre-Glacial Prince River during its earlier history was directed through Mill and Winimusset Brook valleys by way of what is now part of the Ware River Valley.

8. The Tertiary "Muddy" River. The valley of Muddy Brook is one of the most impressive of those crossing the tunnel line (see Plate 1). Study of the topography from the map and in the field suggests that at some time the East Branch of the Swift River flowed through this valley. Upon investigation by borings the divide in the vicinity of Dead Pond was found to be composed entirely of glacial drift. The rock floor of the valley through this area is at about Elevation 480, whereas the surface divide is approximately 70 feet higher.

Reconstructing the pre-Glacial or Tertiary drainage pattern was important in indicating the areas where the underlying rock floor might be lower in elevation than was indicated by surface conditions. The limits of many of the pre-Glacial valleys are obscured by extensive glacial drift deposits of uncertain thickness. Because of the uncertainty as to the topography of the rock floor, such areas were recognized as being more important than others where geologic conditions were more easily interpreted. These preliminary investigations outlined the critical areas throughout which more detailed investigations should be made by diamond drill borings.

Glacial Drift Deposits

The greater part of the area traversed by the tunnels is covered by a glacial deposit known as a ground moraine. This type of deposit is commonly found in an unsorted condition and consists of a heterogeneous mixture of rock flour, sand, gravel, and boulders. It is a relatively shallow deposit compared with other types of glacial drift. In general the ground moraine is found in the higher areas and upon the side slopes of the valleys which, upon retreat of the glacier from the region, carried the glacial waters derived from the melting ice. As a result, this type of deposit, sometimes called hardpan by the engineer, is comparatively free from the assorting effect of water.

During the recession of the glacier many of the valleys were periodically blocked by glacial drift and ice. Water derived from the melting ice was thus ponded, forming temporary glacial lakes which received large quantities of well assorted deposits transported by glacial rivers. This phase of the glacial history may be recognized in the modified character and mode of occurrence of the deposits, which consist largely of stratified fine sand and banded clay or rock flour. The surface topography within these lake areas is generally flat with small irregularities and depressions. One of the most notable of these temporary lakes was the glacial Lake Nashua of Crosby[1] which covered the drainage area of the Nashua River from Boylston to East Pepperell, with an arm running to Fitchburg. The present Wachusett Reservoir occupies a portion of the bed of this lake.

Investigations in the Valleys

Valleys whose outlets were kept open throughout the period of glacial recession contain deposits of a modified character, the irregular structure and coarseness of which indicates an origin other than in the quiet waters of a glacial lake. The lower sides and bottoms of these valleys contain irregularities in the general surface topography in the form of ridges and terraces which are composed mainly of sand and gravel, indicating deposition by glacial streams. Some of these sediments were deposited in front of the retreating glacier as a sheet or outwash, some beneath the ice in sub-glacial river channels, and others on top of the ice. As a whole they form a curious assemblage of flat terrace-like areas and steep and gradual sloped knolls and ridges of varying magnitude. Such deposits of glacial drift are known as kame deposits, fine examples of which are found in the valleys of Muddy Brook and the Swift River.

---

[1] **Op. cit.**

There are also other deposits of a semi-modified and unmodified character whose form and surface character indicate an origin near the front of the retreating ice sheet. Alden[1] has recognized these deposits as recessional moraines, has traced their approximate boundary lines, and has differentiated the several stages of glacial retreat which contributed toward their development. In surficial configuration these deposits form knolls and ridges of irregularly stratified sand and gravel. Irregular or bowl-like depressions, many of which contain small ponds and bogs, are interspersed throughout the morainal area. The difference in the relief of these humps and hollows ranges from five feet to not more than a hundred feet. The topography is not imposing but in general it is peculiar and characteristic, appearing somewhat like a large dump of earth and rock material.

Specific Geological Investigations

Geological investigations of the Quabbin Aqueduct included briefly: (a) construction of an outcrop map; (b) delineating areas where the glacial drift was so thick that the rock floor topography and character were uncertain; (c) tracing of pre-Glacial drainage courses; and (d) explorations by diamond drill borings. Borings carried to and into rock were completed in the conventional manner of doing such work. Since boulders five feet or more in diameter are not unusual occurrences in glacial drift derived from crystalline rock formations, borings were penetrated into ledge for distances varying between 10 and 20 feet in order to be certain that bedrock had been reached. At two of the shaft sites the rock formations were penetrated to a depth of 100 feet.

Investigation in Quinapoxet Valley

The Quinapoxet Valley for a distance of one mile east of Shaft 2 is covered with modified drift laid down in an early stage of Glacial Lake Nashua. Extending east of this section to the vicinity of Shaft 1 the deposits are of the morainal type, forming an almost continuous cover of variable thickness which made investigation by borings necessary. Such rock outcrops as were located indicated that the present stream does not flow in its original channel. Not only was there uncertainty as to the thickness of the deposits but it was impossible to state where the deepest channel in the rock floor was located. An extensive boring program, therefore, had to be planned to secure the necessary data. The greatest depth of drift penetrated by any of the borings (see Figure 3) was found to be 114 feet. Within this valley glacial drift is believed to be deposited to a depth of 175 feet more or less. The lowest point reached by borings in the rock floor of the valley was approximately 400 feet above sea level, causing the depression of the east end of the tunnel to a depth of approximately 200 feet to insure a sufficient thickness of rock cover.

Investigations in Ware-Prince Valleys

Abrupt change of the valley at Coldbrook from a north-south to an east-west course is a striking deviation from the normal trend of valleys throughout the district. A possible explanation of this unexpected change of course has been previously suggested in the discussion pertaining to pre-Glacial drainage courses. The interpretation presumes that the Burnshirt-Ware and Prince-Ware River valleys were originally separated, that during Tertiary time a tributary of the Prince River, etching out the valley now occupied by the Ware, cut through the divide and diverted the other stream. In the earlier stages of its development the Tertiary Burnshirt River flowed by way of the present Burnshirt-Ware valleys as far as Coldbrook, and thence southerly out of the district. The course

[1] Op. cit.

of the Tertiary Prince-Ware River was directed in somewhat the same manner as at the present time. Later the upper portion of the Burnshirt-Ware was diverted into the Prince-Ware course.

A series of seven borings across the Ware River on the site of the diversion dam at Shaft 8 (Figure 4) located the lowest point in the valley floor at about Elevation 607, which is approximately 40 feet lower than the flow line of the present stream. A profile through these borings developed the form of the floor and indicated the extent to which this ancient valley was filled with drift. The deposits throughout this area are of the recessional moraine type, extending southeasterly from this point along the Boston and Maine Railroad, and have partially obscured the Tertiary valley mentioned above. The elevation of the floor at this point favors the conclusion that the Tertiary Burnshirt River was diverted by a backward cutting tributary of the Prince-Ware River, which left the valley floor of the former higher than 600 feet above sea level. A boring placed one-half mile southeast of Coldbrook, at a point probably located within the Burnshirt Valley, found rock considerably above Elevation 600.

To check the reasoned conclusions concerning the geologic history, and also to determine the profiles of these valleys, several borings were made near the confluence of the Prince and Ware Rivers at Barre Plains. These indicated a great thickness of glacial drift over the rock floor. One boring, for example, after penetrating 161 feet of glacial drift showed rock at Elevation 434, which was only a few feet above the projected tunnel grade. That the floor was low at this point had been foreseen, but without further explorations it was not possible to determine whether this condition was confined within the Ware Valley or the Prince Valley or was common to both. In order to determine the extent of this depression, and to fix the point at which it would be safe to cross the valley along a new tunnel line location, several additional borings were located farther east along the tunnel line. These investigations (see profile, Figure 5) indicated that rock along the line in the Ware Valley was sufficiently high for an adequate rock cover over the tunnel and that the low floor section was confined to the Prince Valley. It became necessary then to select a crossing under the Prince Valley where higher rock could be found. From the study of erosional processes, river and glacial, which were responsible for the formation of this valley, it seemed evident that this desirable condition would be found farther north. Consequently, several borings were placed along a new location of the tunnel line, and the result confirmed that conclusion. Subsequent investigations along this line indicated a rock valley buried to a maximum depth of approximately 110 feet. The lowest point of the valley floor was determined to be at about Elevation 480.

One possible interpretation of the facts would account for the low floor at the confluence of the Prince and Ware Rivers as being the result of erosion by the Ware River. This interpretation would assume, however, an abnormal gradient in the rock floor of the Ware Valley throughout the section between Coldbrook and Barre Plains. Additional explorations between these localities indicated that this interpretation was not correct, that the floor gradient of the Ware Valley was normal, and that a large part of the 200-foot drop between Coldbrook and Barre Plains was confined to a relatively small area. Overdeepening of the valley by glacial abrasion appears to be the most reasonable explanation of the origin of this rock depression.

Investigations at the Portal Site

The first steps in the sub-surface investigations of the west portion of the aqueduct were made in Muddy Brook Valley along a line referred to as the "south line." Preliminary studies for the location of the west terminus of the tunnel contemplated the selection of a suitable portal site on the East Branch of the Swift River somewhere south of Quabbin Lake. The portal of the south tunnel trial line was located at a rock cliff a short distance from the Swift River, East Branch, and about one-fourth mile south of the lake. It was found, however, that location of the portal site along the east side of the lake would save from one-fourth to one-half mile of tunnel. It was also believed that a higher rock floor could be found in the valley of Muddy Brook along a line situated farther north. Preliminary studies narrowed the list of promising portal sites to two, one located at the extreme north end of Quabbin Lake and the other about midway between the north and south ends of the lake. Several borings distributed at the most northerly site revealed the surface of rock at a sufficiently high elevation to make a portal at this point feasible, and thus take advantage of the shortest possible tunnel line.

Investigations in Muddy Brook Valley

The valley of Muddy Brook when viewed from the higher ground on either side is an impressive physical feature (see Plate 1). It is a fine example of a large valley now occupied by a stream apparently much too small to have accomplished such an extensive erosional effect. The broad floor of this valley is covered for more than a mile and a half with sand and gravel ridges of glacial origin. Some of the drift is only partially assorted and would indicate accumulation to almost any depth. There is nothing whatever to be seen in the valley bottom from surface inspection that would indicate either the form of floor profile or the quality of rock beneath.

Preliminary field investigations showed an irregular distribution of glacial drift and led to the belief that Muddy Brook Valley was the result of erosion by a pre-Glacial stream but that considerable deepening and widening and removal of minor eminences was accomplished by glacial erosion. How much of an effect these processes had on the final configuration of the rock floor it was impossible to foretell.

A rock profile developed from information obtained from several borings placed across a portion of the valley near the south line crossing (Figure 6) revealed a deeply buried rock floor in which the lowest point was approximately 45 feet above the projected tunnel roof. These explorations having shown a low rock floor on the south line, attention was transferred to the north line crossing, where it was hoped better conditions might be found. The results showed, however, a continuous low floor and also that the present divide in this area between the Ware and Swift River watersheds is formed entirely of glacial drift deposited to a maximum depth of about 140 feet. As a result of these studies, which indicated a rock cover over the tunnel roof of about 55 feet, the north line was accepted as the tunnel location.

Upon reviewing the Muddy Brook problem at a later date it was felt there were still several features which had not been as fully determined as was desirable. Borings on the north line had been located by lining up the lowest known portion of the valley floor as developed on the south trial line with the water gaps observed in the topography toward the northwest. This method, however, left an unexplored portion along the tunnel line in the vicinity of Dead Pond approximately one mile in length, much too long a stretch to be taken wholly for granted. The impossibility of determining from the information at hand just how much of the valley was due to pre-Glacial river erosion and how much to glacial scour was an additional reason for further exploration.

For this particular work it was considered practicable to develop a rock profile with the aid of the surface potential or resistivity method of geo-physical prospecting, by means of which estimates of the thickness of cover or depth to bedrock are based on electrical measurements. In order to be assured of the approximate reliability of the results similar electrical determinations were made at two points where the thickness of cover was already known from borings. In both of these cases the results were consistent with the borings.

A rock profile across the valley floor was thus developed which considerably extended the reliable information. Throughout the section in question the mantle of drift was shown to be rather thick but the elevation of the floor was found to be considerably higher than throughout the section farther west.

THE ROCK FLOOR

The district where the Quabbin Aqueduct is located is so heavily covered with glacial drift that a large part of the bedrock geology is seriously obscured; nevertheless, outcrops are sufficiently numerous to determine certain major features concerning the underlying geologic structure. The several rock formations occurring in this section of the state have been defined by Emerson[1] and their areal extent has been indicated on the geologic map of Massachusetts and Rhode Island. This geologic information was accepted as a working basis and proved to be immensely helpful. In reality it became the ready-at-hand guide in the early reconnaissance studies.

---

[1] Emerson, B. K., Geology of Massachusetts and Rhode Island, U. S. G. S. Bulletin 597, 1917.

It was clear from these published sources of information and from field studies that several different rock formations, all of them crystalline, would be penetrated by the proposed tunnel. Some of the formations are metamorphosed bedded sediments while others are of igneous origin, the chief igneous rock being granite. The metamorphosed rocks vary from very fine-grained rocks, intermediate between slate and mica schist called phyllites, to fairly coarse-grained schists. Occurring with these are occasional beds of quartzite which in general are more massive than the schists. As a whole, the rock formations were considered to be of good quality and where they had not been disturbed too much by deformation it was felt they would not be likely to give trouble of any consequence during construction. A certain amount of faulting, where the rock might be badly broken, was anticipated, and it was believed that such weaknesses would be encountered despite the fact that no important fault could be located by surficial examination. The fact that nothing of this nature could be located was not considered significant because such features under weathering and erosion develop readily into depressions which later become obscured, thus removing from observation the very places of most concern to the engineer.

Before construction began a final review was made of all the old and new facts bearing on the tunnel project as well as the several questions previously raised.

The preliminary and more detailed geologic studies made it possible to answer some of the questions completely. It was readily determined that there were at least seven important geologic units sufficiently uniform within their own boundaries and yet varying enough one from another to be regarded as different geologic formations. It was also possible to determine approximately the formational sequence from one end of the tunnel to the other and indicate the length of tunnel within each formation. It was impossible to make a definite statement as to the location of faults or crush zones as none of importance were discovered in the exploratory work. It was necessary, however, to anticipate the probability of encountering such zones and to be prepared to provide timbering for the tunnel excavation through them.

It was apparent that the tunnel could be constructed successfully along any of the alternative lines so far as the rock formations themselves were concerned. Such structural weaknesses as might be encountered were expected to cross the tunnel line and would be encountered regardless of which line was followed. The choice of lines, therefore, turned, not on the character of the rock but directly upon its topography, especially the depths of buried channels, and also upon the relative advantages of the portal sites.

Record of Geologic Features of the Tunnel

A plan of recording geologic features was used that is believed to be particularly suited to projects of this kind. Special attention was given to four kinds of records; first, systematic field notes of observations taken directly from the tunnel walls, and transference of this data to a geologic section drawn as a profile of the tunnel; second, collection of typical samples representing the average of rock formations and any special conditions; third, a series of photographs of characteristic structures and underground conditions; and fourth, notes on special features and on rock interpretations which it is hoped will serve as a contribution to the geology of central Massachusetts.

The Geologic Section

In recording the geologic phenomena observed in the tunnel a continuous floor plan and sidewall profile was drawn on a scale of twenty feet to an inch. Plan and section are drawn side by side, giving opportunity to show graphically the strike of structures on the plan and the dip on the section.

Different rock types are indicated by characteristic conventional designs and all special structural features are represented, including formational boundaries, bedding, joints, and internal features such as the foliation or grain structure. Additional features which do not lend themselves to graphic representation are indicated in descriptive notes on the drawings at the point of occurrence so that the geologic plan and profile carry a continuous series of abbreviated descriptions. Sixty such drawings are appended to this report.

Rock Samples

Hand specimens were taken systematically and continuously from a large part of the tunnel at 25-foot intervals. In certain stretches where the geologic conditions were more uniform and monotonous, samples were taken at 50, 100 or 250-foot intervals. In addition, whenever it seemed advisable, suites of specimens were collected for special study.

All of these rock samples have been properly labelled and arranged and are permanently housed in the intake building at Shaft 8 near Coldbrook where they furnish a visible record of the actual rock excavated throughout the entire length of the tunnel.

Photographic Record

In addition to the detailed geologic record presented on the profile sections, photographs were taken of those spots where features of special interest and significance were encountered. These features are mostly of a structural character and include banded or injection structures of pegmatite and granite in the schistose rocks, streaked and banded or flow structures characterizing the granite masses, and deformation structures of all kinds, particularly folds and joints. In this manner some of the characteristic details have been preserved with greater exactness than could otherwise have been done.

Geologic Interpretation

It is intended to give here a summary of the geologic returns of the Quabbin project. This portion of the report is essentially a composite of data gathered from all possible sources and assembled into as comprehensive a statement as seems justifiable. It, together with the other forms of records referred to under the preceding heads, is intended as a contribution to the geology of central Massachusetts.

Rock Formations

All rocks of the area have been greatly modified by metamorphic processes. Despite the great variety, the rocks may be grouped rather satisfactorily into three classes: (1) those of sedimentary origin, (2) those of igneous origin, and (3) those of doubtful origin consisting chiefly of hybrid or mixed rocks, in part igneous and in part sedimentary. In the excavation of the tunnel, two principal types of schist were penetrated. One of these is a brownish quartz feldspathic biotite mica schist typically developed between Shafts 4 and 5. This in general corresponds to the Paxton quartz schist of Emerson.[1] Another type is a brownish quartz mica (mainly biotite) schist typically developed between Shafts 3 and 4, 7 and 8, 9 and 10, and at Shaft 11. This is the Brimfield schist of Emerson.[2]

The Paxton feldspathic biotite schist is made up of two units separated by a distinctly different type, which is similar to portions of the Brimfield schist. The Paxton formation, therefore, is composed of three members, which have been designated as the upper, middle, and lower Paxton members.

The Brimfield schist type was found distributed both above and below the Paxton formation. Because of this it was necessary to recognize a new formation which has been called the Ware schist.[3]

Rocks of igneous origin occur throughout the tunnel, the most prominent occurrences being those of a gray gneissoid granite between Shafts 1 and 3 and 11 and 12. The granite occurring within the former limits has been mapped by Emerson[4] as part of the Fitchburg granite, and that within the latter limits as the Monson granodiorite.[5] A very dark granitic gneiss, called the Hardwick granite[6], occurs between Shafts 10 and 11.

---

[1] Emerson, B. K., op. cit., p. 62.

[2] Emerson, B. K., op. cit., pp. 68–71.

[3] Callaghan, E. A., Contribution to the Structural Geology of Central Massachusetts, Annals of the New York Academy of Science, Vol. 33, p. 63.

[4] Emerson, B. K., op. cit., pp. 232–233.

[5] Op. cit., pp. 241–243.

[6] Op. cit., pp. 238–239.

The areal distribution of formations is shown in Figure 7. The distribution, except for minor revisions, is essentially the same as that shown by Emerson.[1] In a few cases, formational boundaries have been redrawn to conform to the contacts exposed in the tunnel. The rocks of the large area mapped by Emerson as Brimfield schist in Hubbardston granite have been given new significance by assigning them to and mapping them as a new formation called the Ware schist. The designation of Hubbardston granite on the preliminary map has been dropped in the interest of simplification. As brought out in this report the Hubbardston granite is merely a special facies of the Fitchburg granite, which has intruded the schists and formed injection schists and gneisses. In a few cases this condition is shown on the map by a pattern similar to that designating the Fitchburg granite.

Emerson's classification of Brimfield schist has been retained, although occurrence of this type in four separate belts between Shaft 8 and the portal has been shown on the geologic section, Figures 8D, E and F, as Brimfield-Ware schist. Formations of only indirect concern to this report have been grouped. These include the sandstone and shale strata and diabase intrusions of the Connecticut Valley area, which are shown by only one pattern, and which are classified as "Triassic Sediments and Diabase Flows—Dikes." The rocks west of the Connecticut Valley are likewise grouped under a single pattern and are classed as "Schists and Gneisses West of Connecticut Valley." The Paxton schist formation, newly recognized as being composed of three members, is shown by a single pattern, because the areal distribution of the component parts is not known in sufficient detail to warrant mapping them. It might be noted that Emerson has mapped a few small areas of Brimfield schist enclosed by Paxton schist, which probably could be classed with the middle member of the Paxton formation. Additional exposures of diabase are shown, which are parts of several intrusive dikes emanating from the much larger diabase intrusions of the Connecticut Valley area.

The Worcester Phyllite

This formation does nor occur within the tunnel area. It has, however, an important bearing on the structural as well as the age relations of the tunnel formations. The Worcester Phyllite at its type locality, the Worcester "Coal Mine," has been recognized by Emerson and Perry[2] to be of Carboniferous age. This conclusion has been substantiated by White.[3]

In the "Coal Mine" area the rock is a distinctly carbonaceous and graphitic phyllite. The typically graphitic variety is very black and dense and is composed essentially of quartz, magnetite, biotite, and sericite minerals, together with variable amounts of ferruginous and carbonaceous earthy materials, all of which are thoroughly recrystallized. The whole rock exhibits a strong foliation, grain, or bedding.

A variation in composition is shown in the occurrence of a dark gray to black phyllite having a uniform but extremely fine grain and composed chiefly of quartz and muscovite mica or sericite in about equal amounts. It is very strongly laminated and often presents a distinctly slaty cleavage, although in some places the laminations are wavy, contorted, and crumpled, even down to microscopic scale (Plates 2 and 3).

The phyllite contains many large and small quartz veins which follow the foliation structure in all its detail of folds, crumples, and small distributed faults. Where more strongly quartzose beds are interbedded with the phyllite the quartz veins cut across the foliation without any trace of folding or contortion.

A common feature of the contact zone between the quartzite and phyllite in the area north of the Wachusett Reservoir and the fossil bearing outcrop of the "Coal Mine," is the occurrence of andalusite crystals. These do not penetrate the more quartzose beds but lie in all directions within the darker phyllitic layers. Emerson[4] has previously reported the occurrence of this andalusitic rock over an extensive area in Lancaster and Sterling and designated it as chiastolite schist. In the geologic section (Figure 8A) the phyllite is shown as folded into a simple dome or anticline on the west and a trough or syncline on the east, the major portion of the arch having been removed by erosion, exposing the underlying quartzite.

---

[1] Op. cit., Preliminary Map of Massachusetts and Rhode Island.
[2] Emerson, B. K., and Perry, J. H., Geology of Worcester, Mass., 1903, p. 29.
[3] White, Chas. David, Age of the Worcester Phyllite, Jour. Wash. Acad. Sci., 1912, pp. 114–118.
[4] Op. cit., pp. 64–65.

The Oakdale Quartzite

In the easterly end of the tunnel (Figure 8A) there is an extremely fine-grained light to dark gray and reddish-brown phyllitic quartzite, which, according to Emerson, is part of the Oakdale quartzite formation. The composition of this is quite variable. In general it varies from a phyllitic quartzite or quartz-mica phyllite to a true quartzite. In its simplest facies it is composed chiefly of quartz and rather abundant carbonate (calcite or dolomite) with small amounts of zircon. It is distinctly granular but is nowhere thoroughly recrystallized although quartz, feldspar, carbonate, sericite, and magnetite are present as recrystallized minerals. A variation in color to reddish brown is due to very fine biotite mica, and that to a greenish gray is thought to be due to secondary chlorite, although other investigators have noted actinolite in small lenses which also might account for this color. Another variation seen in hand specimens on the surface, but which could not be recognized in the tunnel, is the segregation of biotite mica in thin bands.

Discontinuous quartz veins are almost always present, but never in association with feldspar. They more often occur with sharply defined borders, sometimes offset, revealing small faults. Introduced carbonate is very abundant—especially in the form of thin-vein fillings in the zones of greatest fracturing. Carbonate also occurs as a very thin veneer on some joint surfaces.

Surface exposures east of the tunnel (Plate 2) show a rock of somewhat variable composition varying from a massive quartzite to a very finely laminated phyllitic quartzite or quartz-mica phyllite. This rock is light to dark gray in color, and contains sericite which imparts a typical silvery sheen to cleavage blocks. Laminae average 2 to 3 mm. in thickness, and near the interbedded quartzite and phyllite are observed to lie closely parallel to the true bedding. In some areas the small crumples of the laminae appear to have been overfolded toward the west, but one small fault was observed which showed an overthrust toward the east. The grain size is everywhere strikingly uniform. When weathered the quartzite tends to break readily along the foliation planes and presents a somewhat leached appearance which is due to attack on the fairly abundant carbonate constituents.

The quartzite, east of the narrow belt of phyllite occurring within the reservoir near Oakdale, forms a belt approximately 1½ miles wide. It is regarded as an anticlinal structure or dome as indicated in the geologic section. West of an area of phyllite it again appears in a belt about one mile wide dipping toward the west where it grades into the Boylston schist.

The Boylston Schist

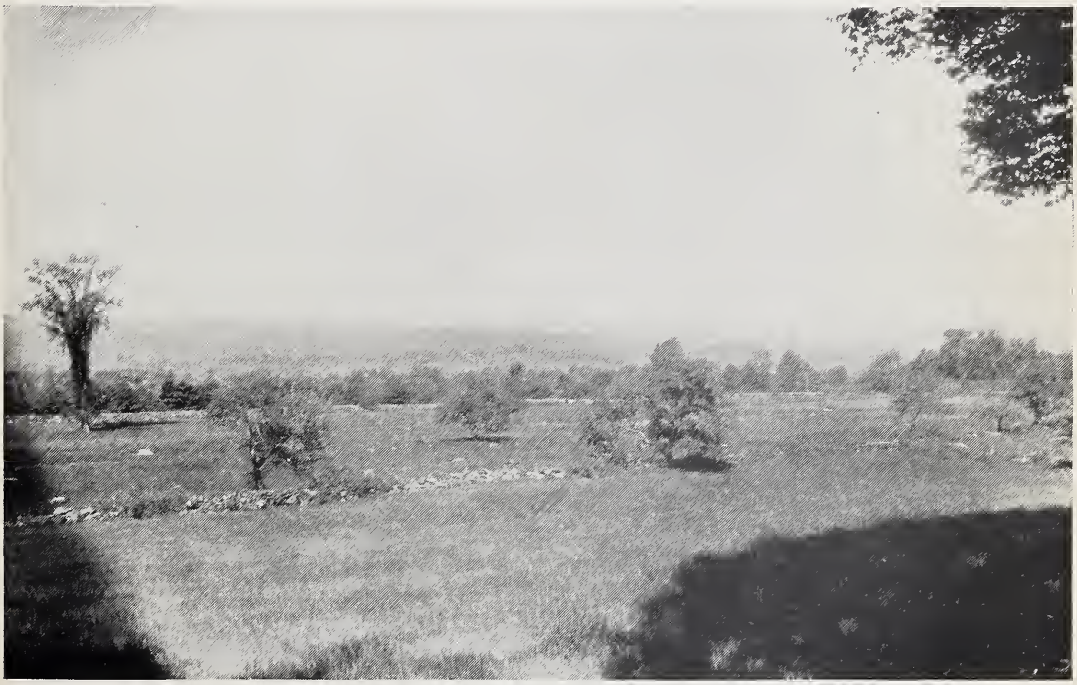
The weathered exposures of this rock present a rusty brownish color, but fresh fractures reveal a bright silvery appearance. In the tunnel the schist has a uniform grayish color and appears to have a somewhat variable composition. The rock generally occurs as interbedded layers and is composed of two principal varieties, namely, a fine-grained quartzose schist or phyllite and a coarser more micaceous schist. The quartzose varieties vary in occurrence from narrow bands a fraction of an inch thick to massive beds several feet thick constituting the major portion of the rock. The coarse micaceous bands are usually minutely crumpled and crushed.

The quartzose bands could be termed quartzites. They have an average grain size of 0.1 mm., and in addition to the abundant quartz contain perfectly oriented muscovite and biotite mica and chlorite minerals and occasionally garnet and pyrite (Plate 3).

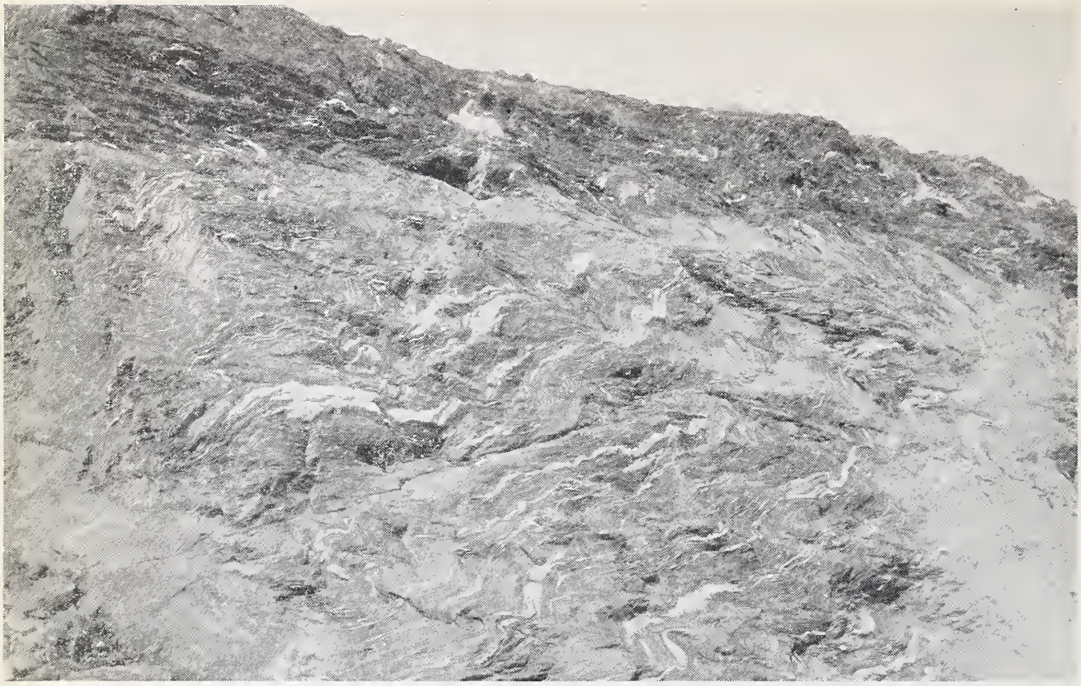
Andalusite crystals are frequently present in the more micaceous bands. The foliation is often seen to be displaced around these crystals and is sometimes curved and contorted. The crystals are larger and more abundant in the vicinity of pegmatite and quartz intrusions. Alteration of andalusite to an aggregate of fine biotite and muscovite mica is indicated on the embayed or irregular mar-

Plate 1

Outlet Works at Shaft 1.
View of Quinapoxet River and Wachusett Reservoir.

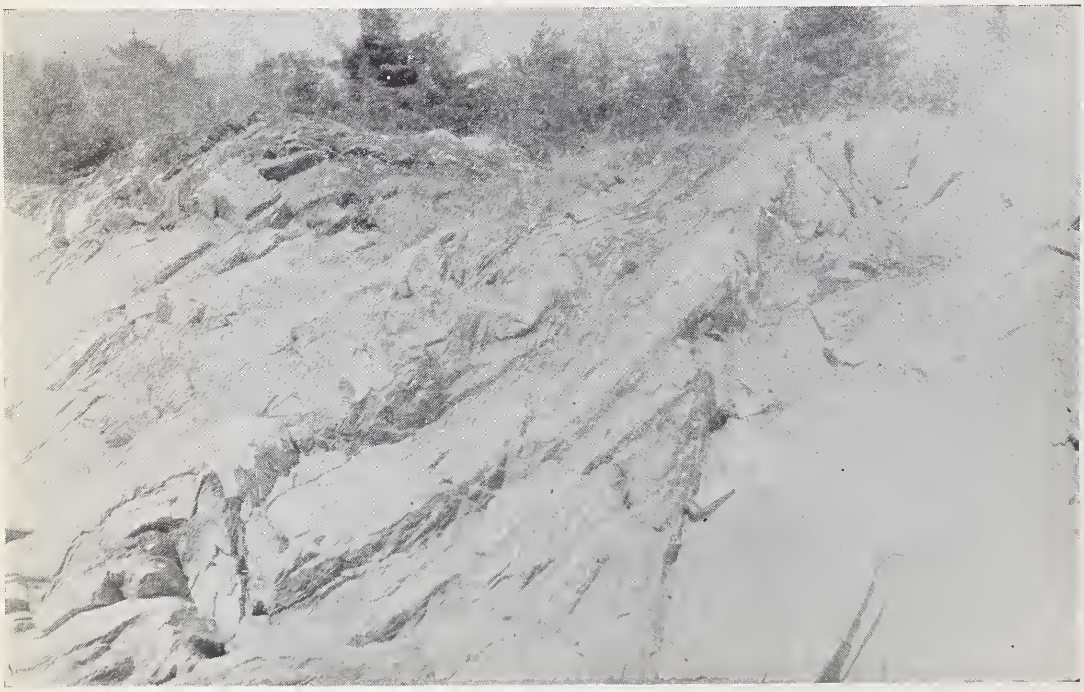


Muddy Brook Valley.
The Cretaceous peneplain is traced by the distant skyline.



Crumpled Phyllite.

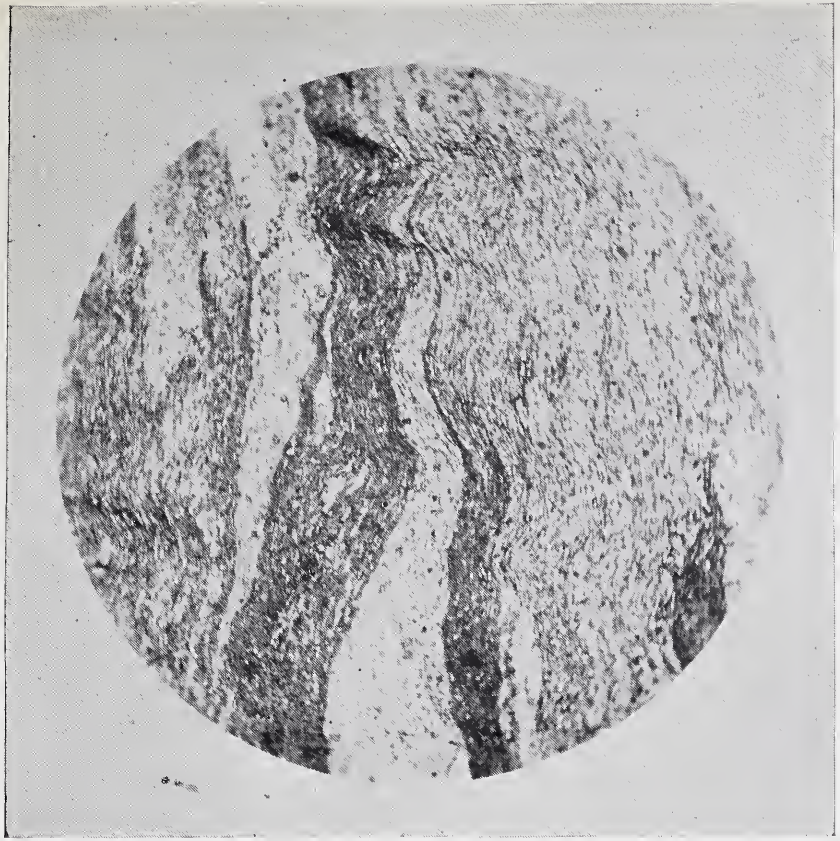
This view was taken on north shore of Wachusett Reservoir in area mapped as Worcester phyllite. The minutely contorted structure and sinuous bands of vein quartz are typical of the formation.



Crumpled Interbedded Quartzite and Phyllite.

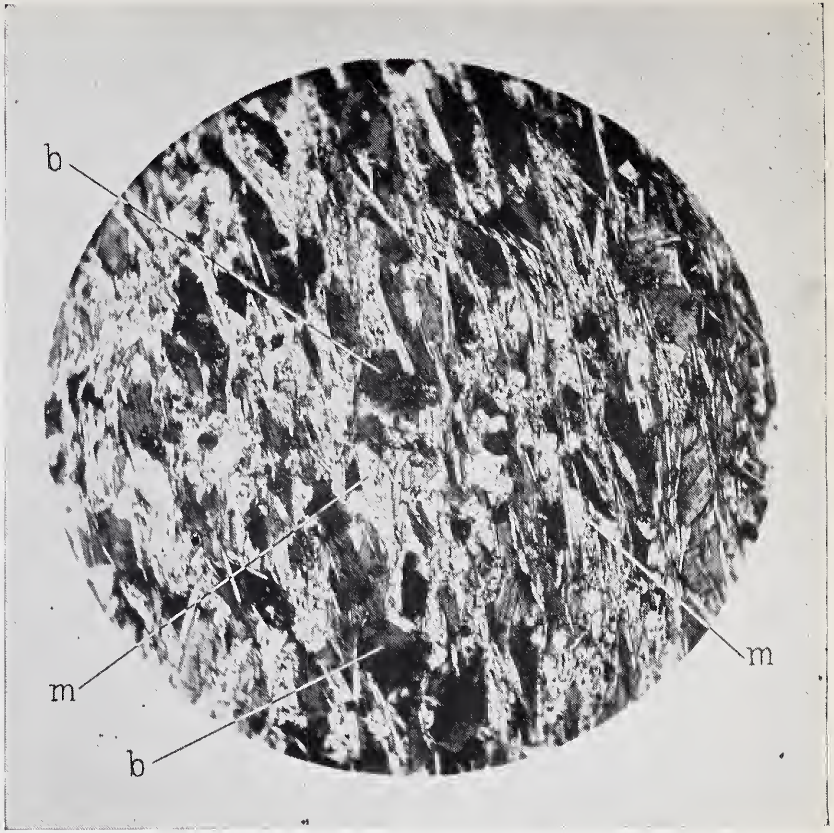
A feature is the strong crumpling of phyllitic layers. The small overthrust faults are displaced toward the east and the narrow sinuous bands are vein quartz.

PLATE 3



Photomicrograph in plain light showing the structure and general composition of the Worcester phyllite. Note the crinkled deformation structure and the fine streaked habit of the rock. The light and dark portions are made up of the same constituents but in variable proportions, the lighter portion being very fine granular quartz and the darker chiefly fine flaky mica.

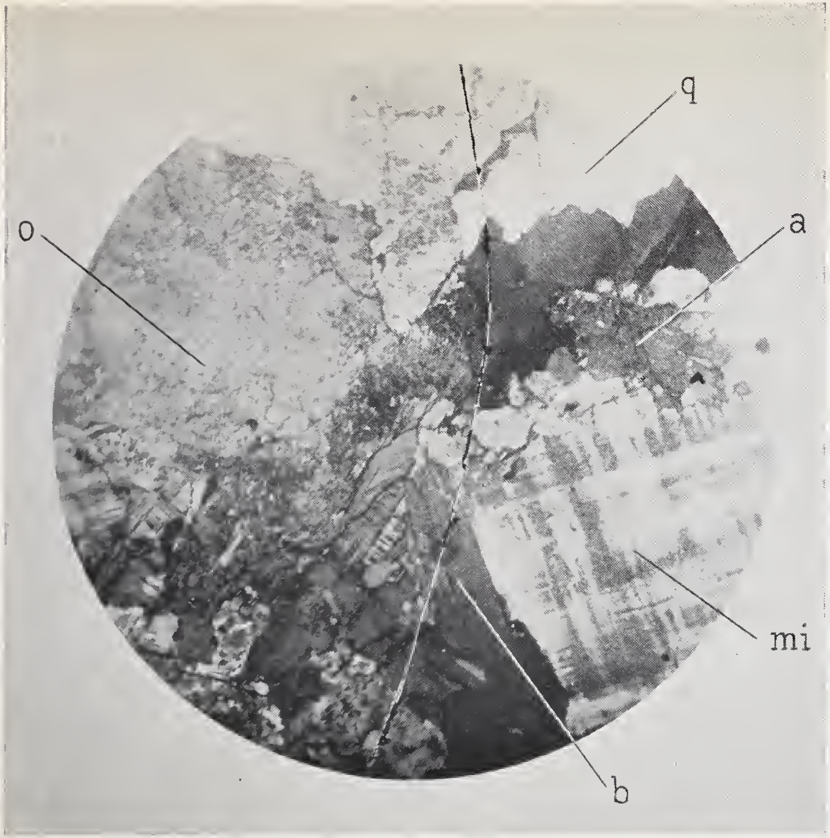
Magnification 30 ×



This photomicrograph in plain light shows the internal structure and composition of the Boylston schist. Note the strong schistose structure resulting from the orientation of light and dark mica. The scattered large flakes are biotite mica (b), and the light shreds are muscovite mica (m). The other constituents are chiefly quartz and granules of magnetite.

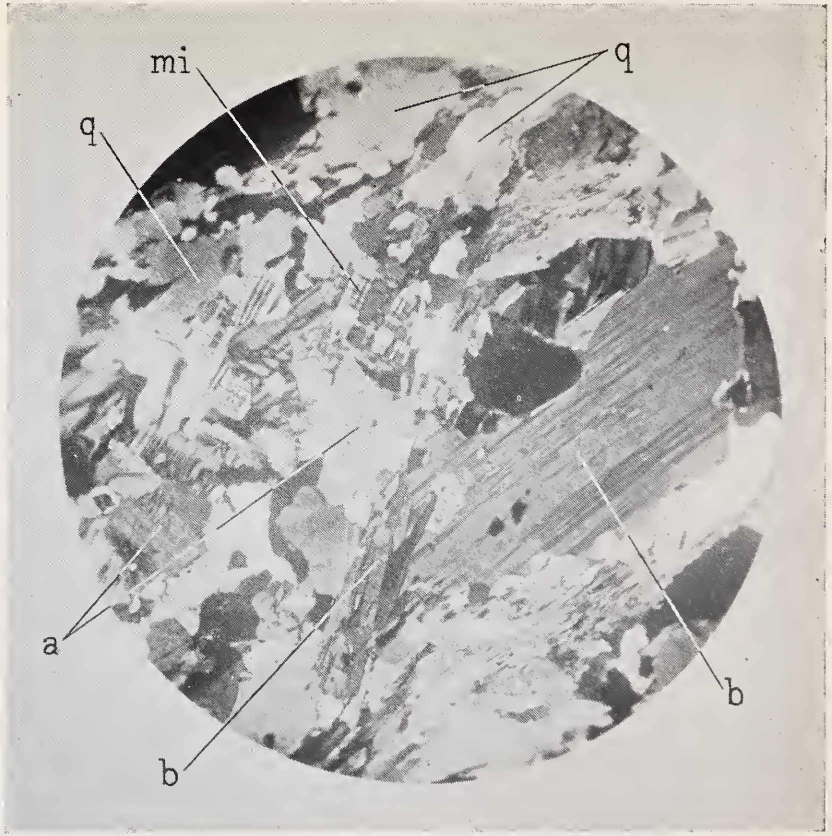
Magnification 30 ×

Plate 4



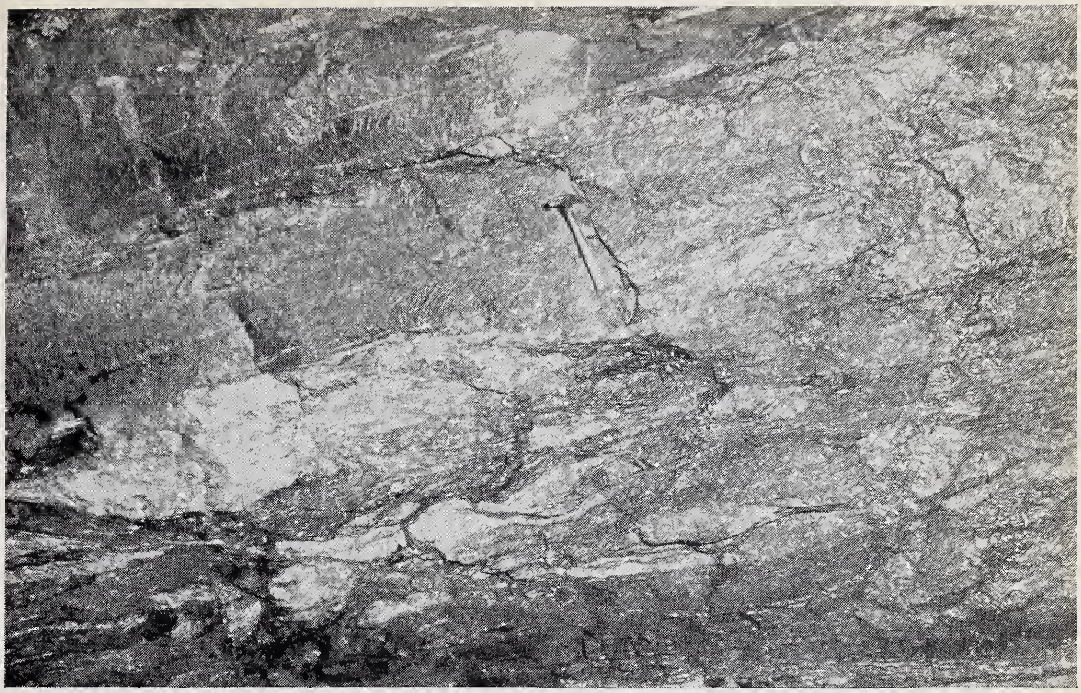
Photomicrograph of normal Fitchburg granite. The rock is composed of orthoclase (o), microcline (mi), albite (a), quartz (q), biotite (b), and muscovite, with small amounts of accessory minerals, apatite and zircon. There is a little secondary alteration producing small amounts of sericite (light specks on the feldspars), chlorite, and iron oxide. The rock is massive and the most noticeable feature is its composition, at least 95% being feldspar and quartz.

Magnification 30 ×



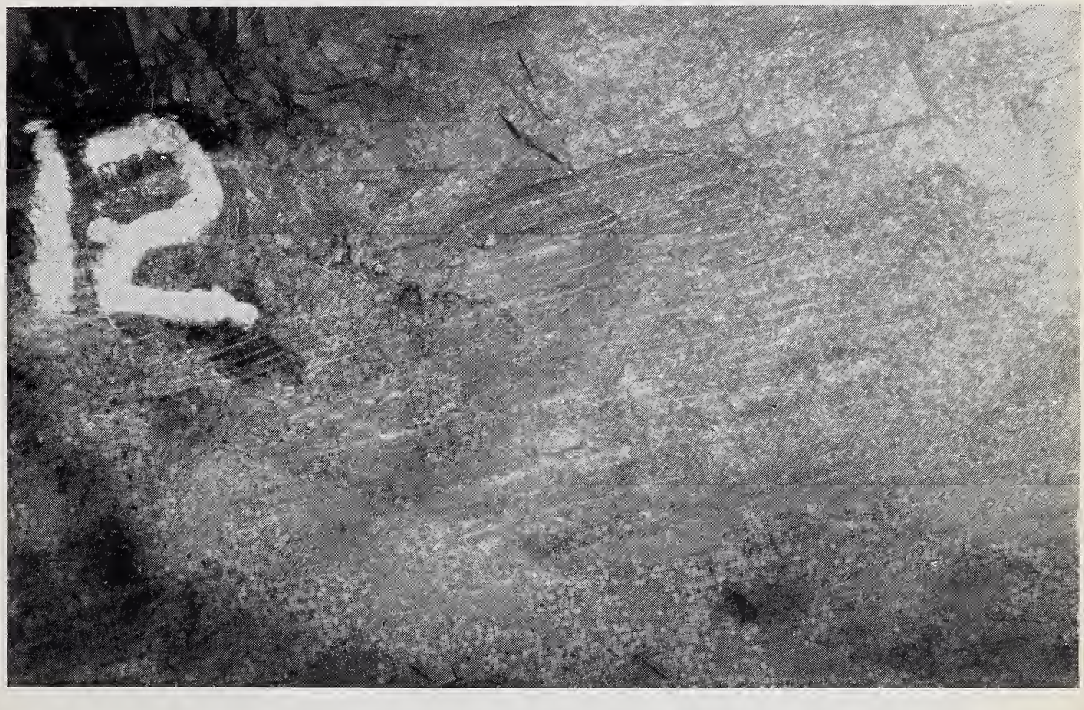
Photomicrograph of Fitchburg granite of gneissoid habit taken in polarized light for comparison with normal Fitchburg granite from which it differs in texture, structure, and compositional proportion. The constituents are essentially similar, microcline (mi), and albite (a) being the principal feldspar representatives, which are associated with abundant quartz (q), biotite (b), and muscovite. The accessory minerals are zircon, magnetite, and apatite. This rock, because of its strong foliated structure and mineral content, is judged to be of a mixed character, containing material derived both from the older schist and from the granite magma, which was intruded. Magnification 30 ×

Plate 5



Brimfield Schist.

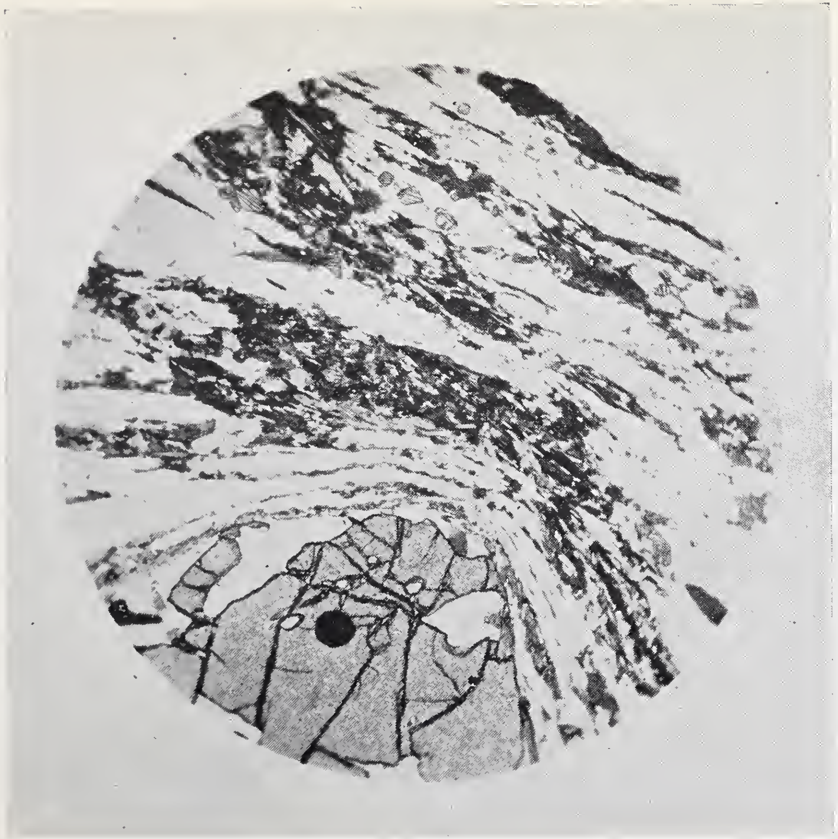
The massive beds are quartzite. The remaining portion shows the typical biotite schist containing small lenses and bands (light patches) of pegmatite.



Typical Banded Paxton Schist.

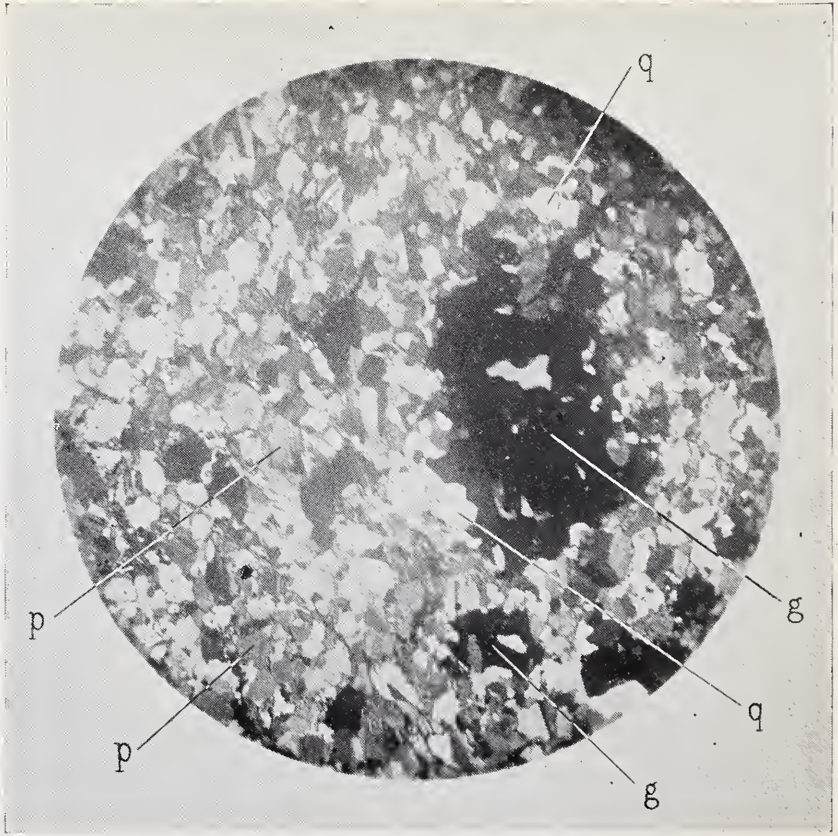
The narrow light-colored bands are parallel to the foliation and bedding structure, and indicate original sedimentary layers. The persistence of such structural features made it possible to reconstruct the geologic section with considerable accuracy.

PLATE 6



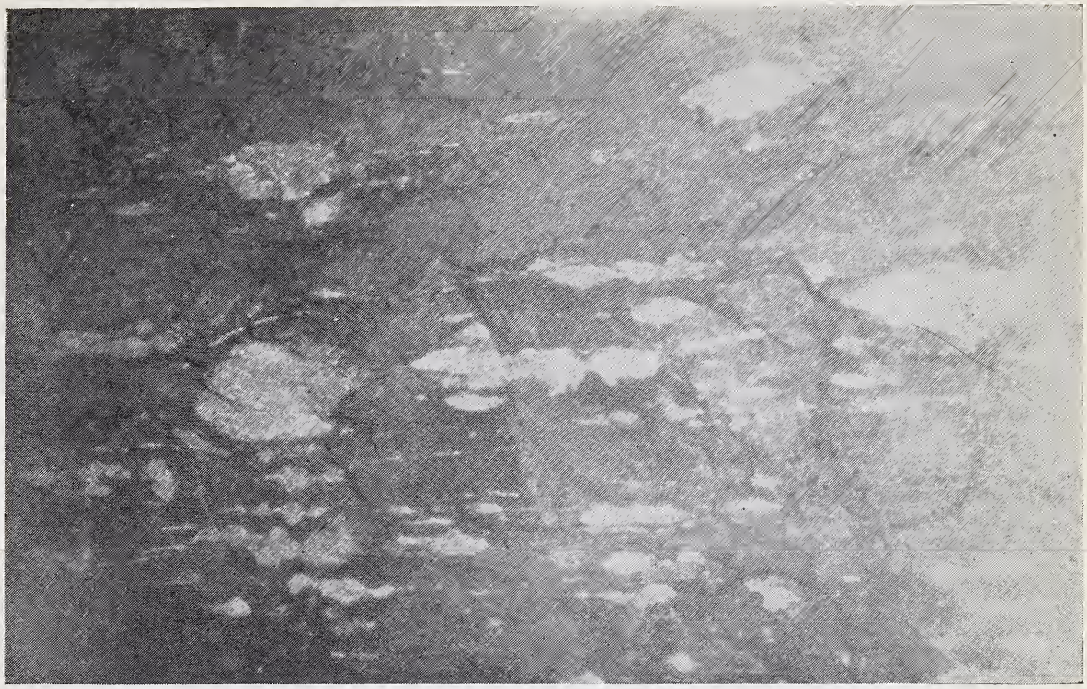
Photomicrograph of Brimfield schist taken in plain light. The foliated structure of the rock is a notable feature. The light streaks are made up chiefly of quartz. The dark streaks are chiefly biotite, with small amounts of accessory constituents. A large garnet is shown at one side of the field.

Magnification 30 ×



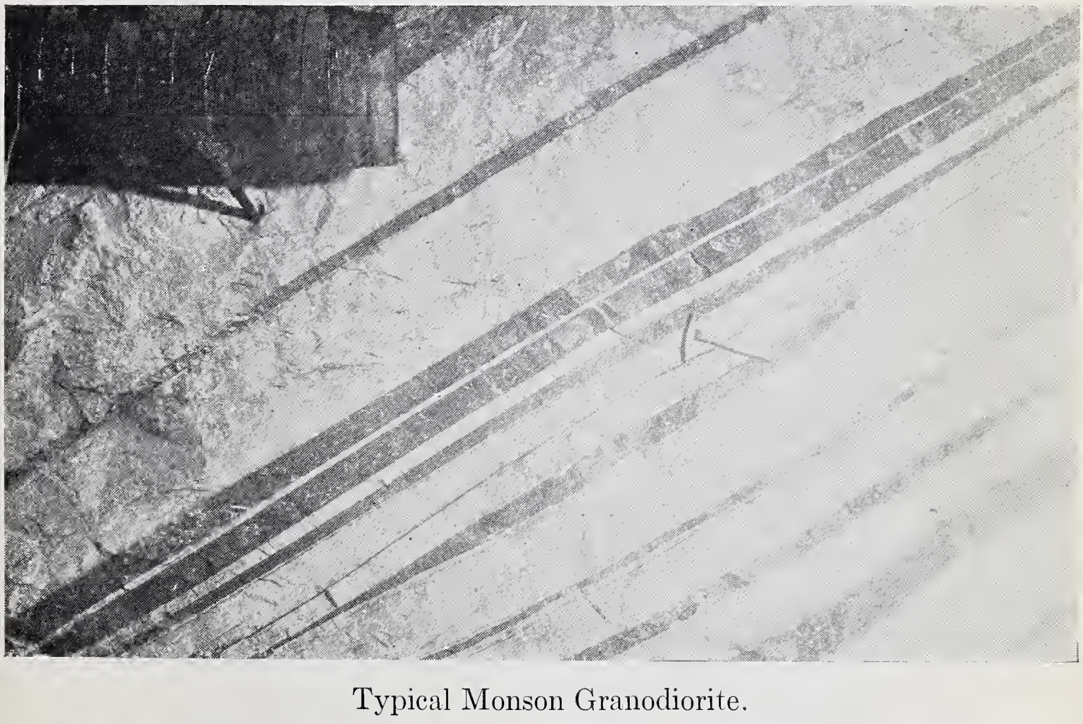
Photomicrograph in polarized light of phyllitic quartzite, which occurred as a band in the Hardwick granite. The most striking feature in composition is the abundant occurrence of quartz (q) and large sprawling garnets (g). The other constituents are plagioclase feldspar (p), together with biotite and hornblende and a little chlorite, graphite and pyrite. This unusual mineral association indicates the rock to be a recrystallized sediment.

Magnification 30 ×



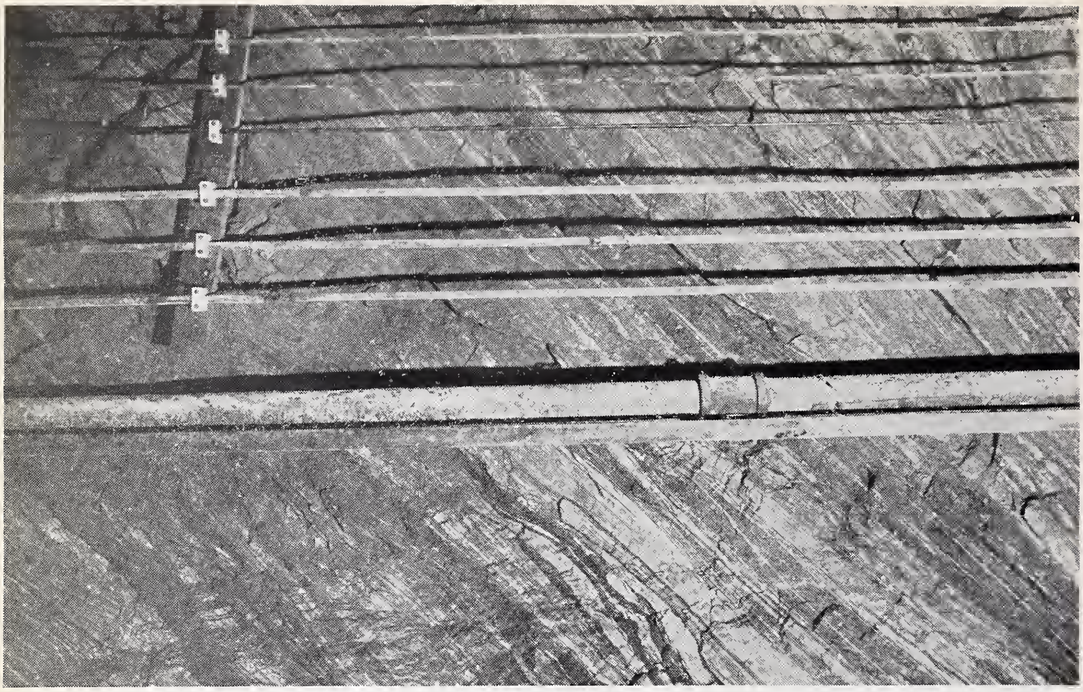
Pegmatite in Paxton Schist.

Such small lenticular bodies are very numerous, and are commonly grouped along the structure lines of the rock.



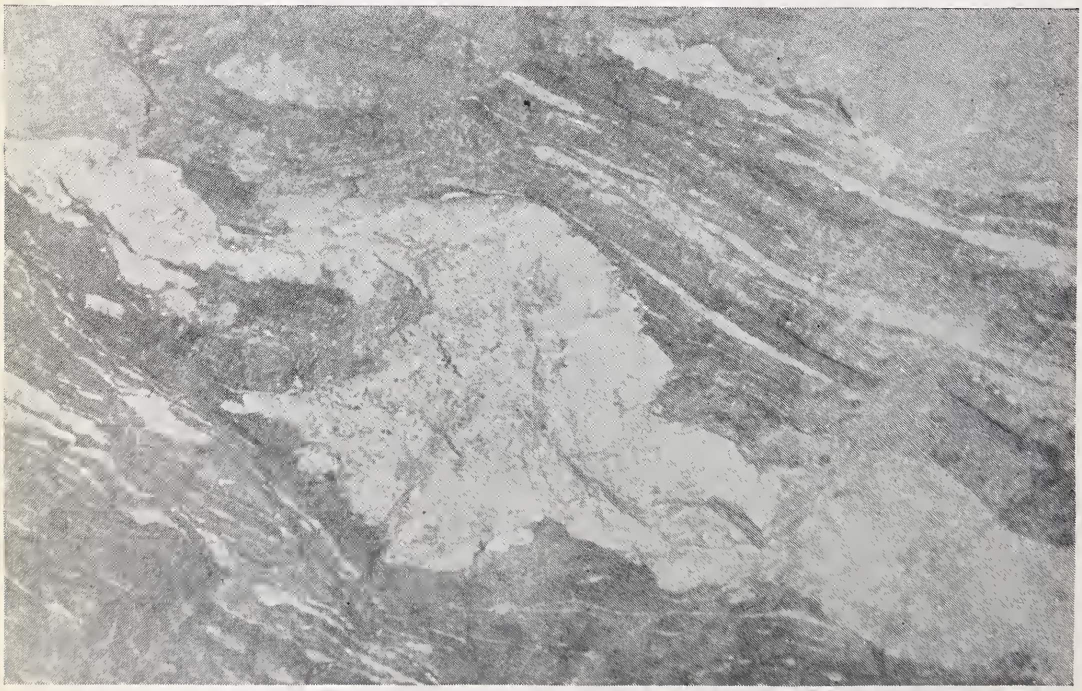
Typical Monson Granodiorite.

The dark bands which occur throughout the formation are hornblende diorite.



Banded Aspect and Structure of Monson Formation.

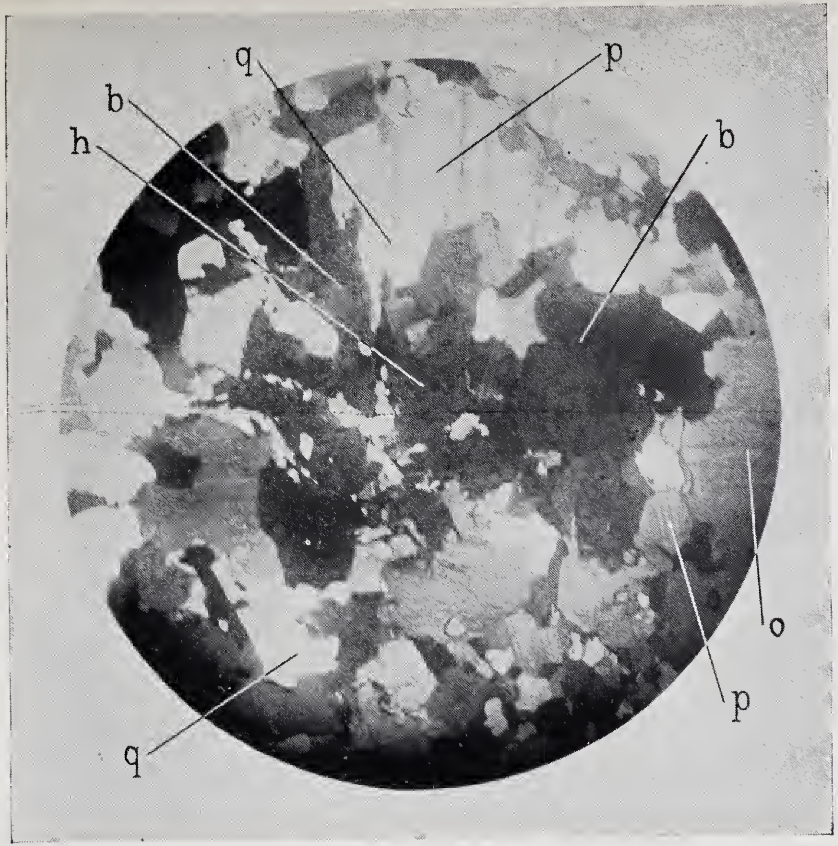
This view is typical of some portions of the Monson granodiorite formation where portions of unreplaced schist occur. The darkest bands are biotite schist. The lighter bands are due to variations in the amount of igneous injection and replacement.



Original Sedimentary Bedding and Igneous Injection of Paxton Schist.

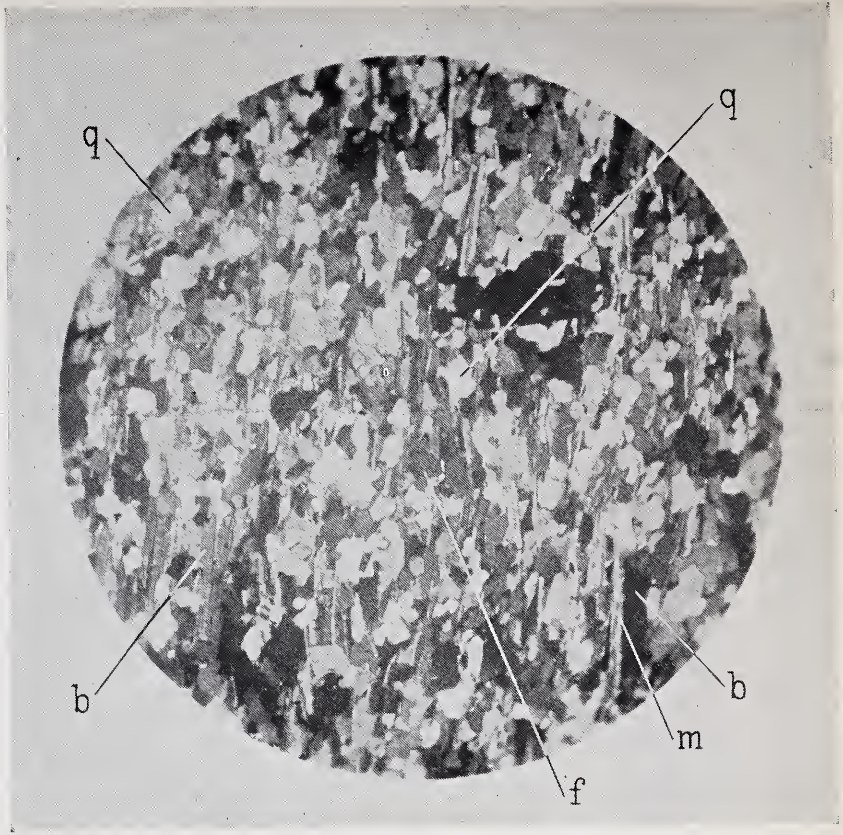
The narrow banding was produced by the arrangement of different layers in the original sediment and by injection of pegmatite in bands and small lenses along the foliation structure. The large irregular pegmatite body is about three feet thick.

PLATE 9



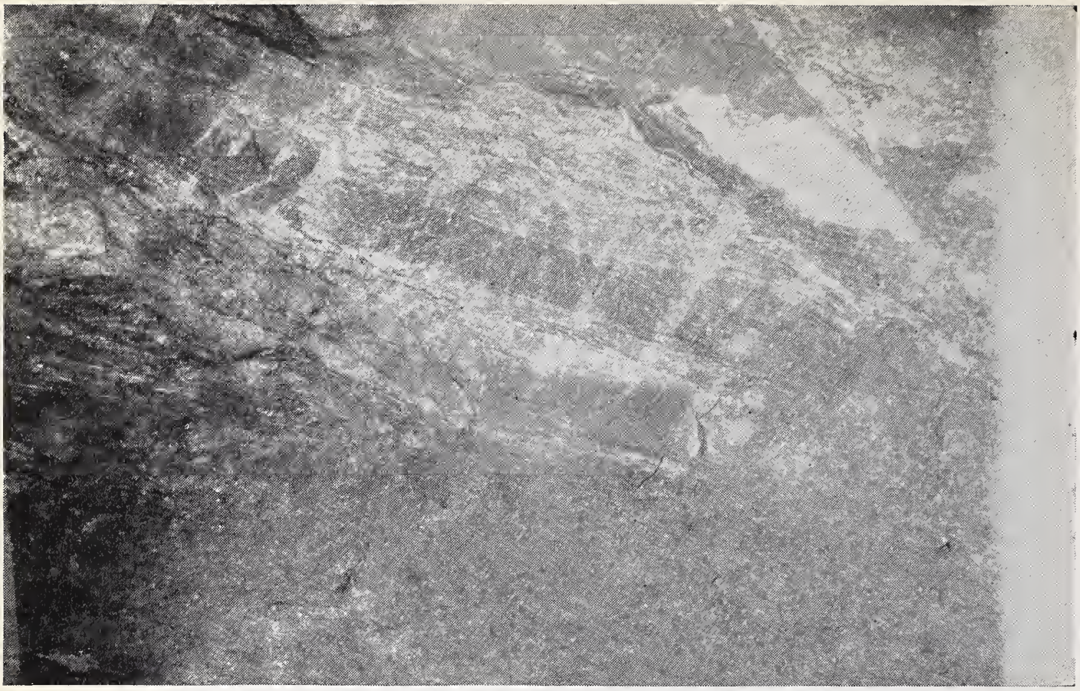
Photomicrograph in polarized light of Monson granodiorite. The rock is of fairly simple composition, the chief constituents being quartz (q), plagioclase feldspar (p), orthoclase feldspar (o), biotite mica (b), and hornblende (h). This composition and the massive structure indicates an igneous origin.

Magnification 30 ×



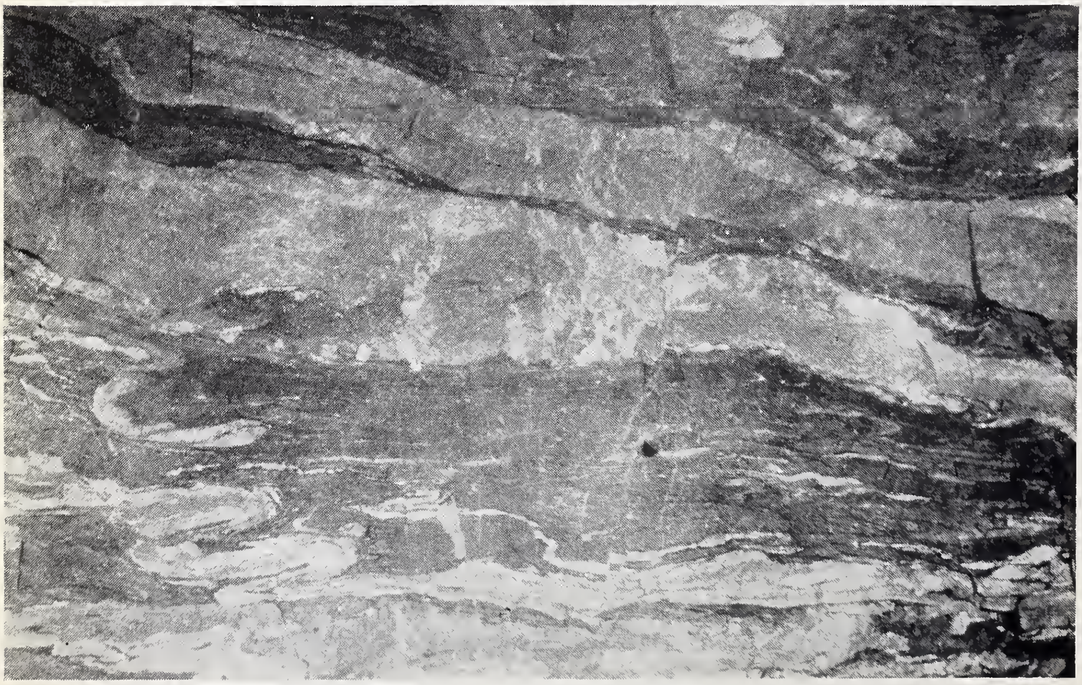
Photomicrograph in polarized light of schist remnant in Fitchburg granite. The rock is made up of abundant quartz (q) and a little feldspar (f), together with recrystallized minerals such as biotite (b) and muscovite (m). Other constituents include fibrolite, zoisite, garnet, magnetite and occasionally tourmaline. The strong foliation structure is a feature, and there is no doubt about it being a metamorphosed sediment.

Magnification 30 ×



Structural Features, Gneissoid, Granite and Pegmatite in Ware Schist.

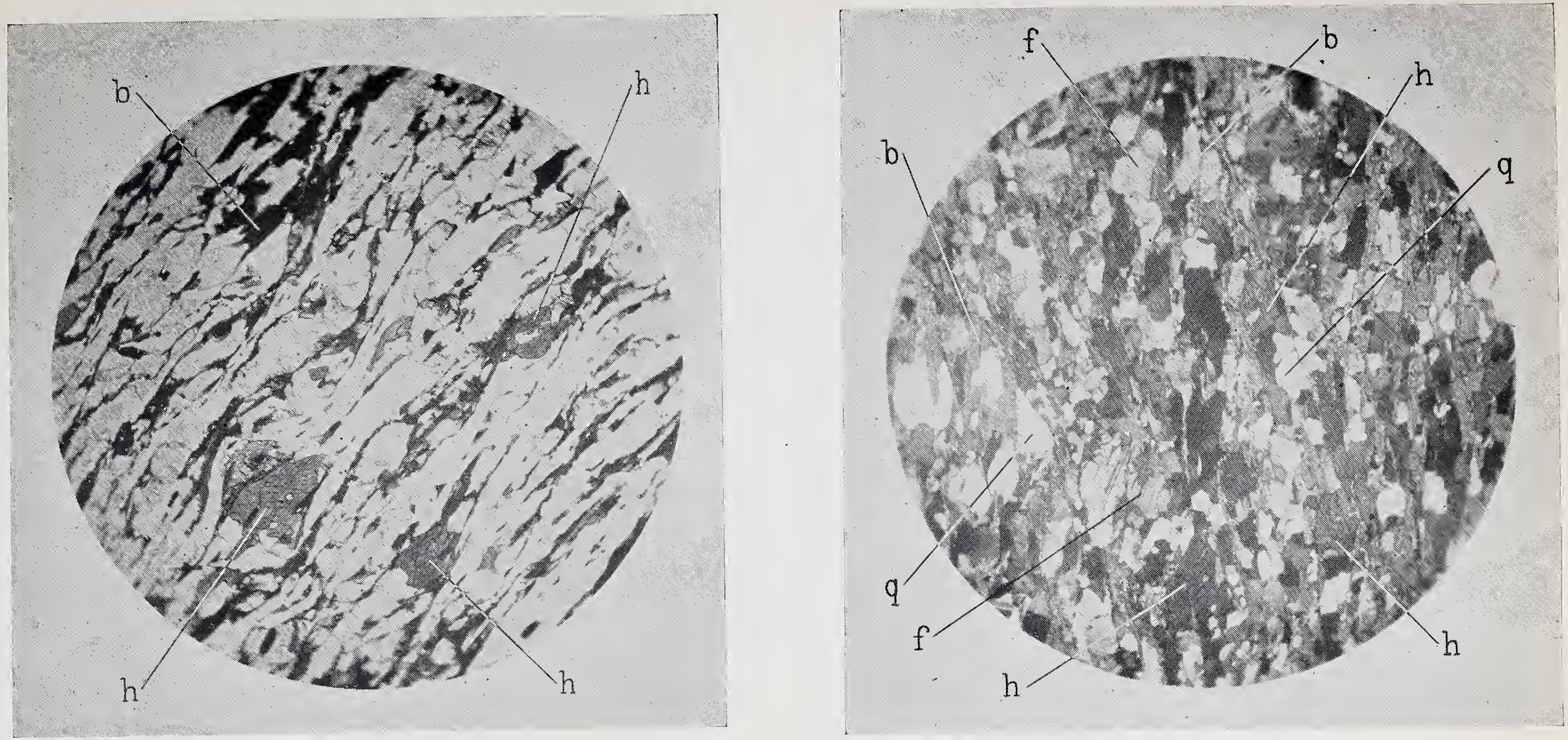
The conformity of the foliation structure in the schist and granite portions suggest that granitization was accomplished by soaking of the schist with granitic material. The dark band extending across the field is schist, above and below which the granitic constituents are abundant. There are also numerous clearly outlined lens-like patches of pegmatite.



Remnants of Granitized Schist in Fitchburg Granite.

The extreme degree of igneous injection and soaking shown here is typical of a large part of the Fitchburg granite as seen in the tunnel.

Plate 11

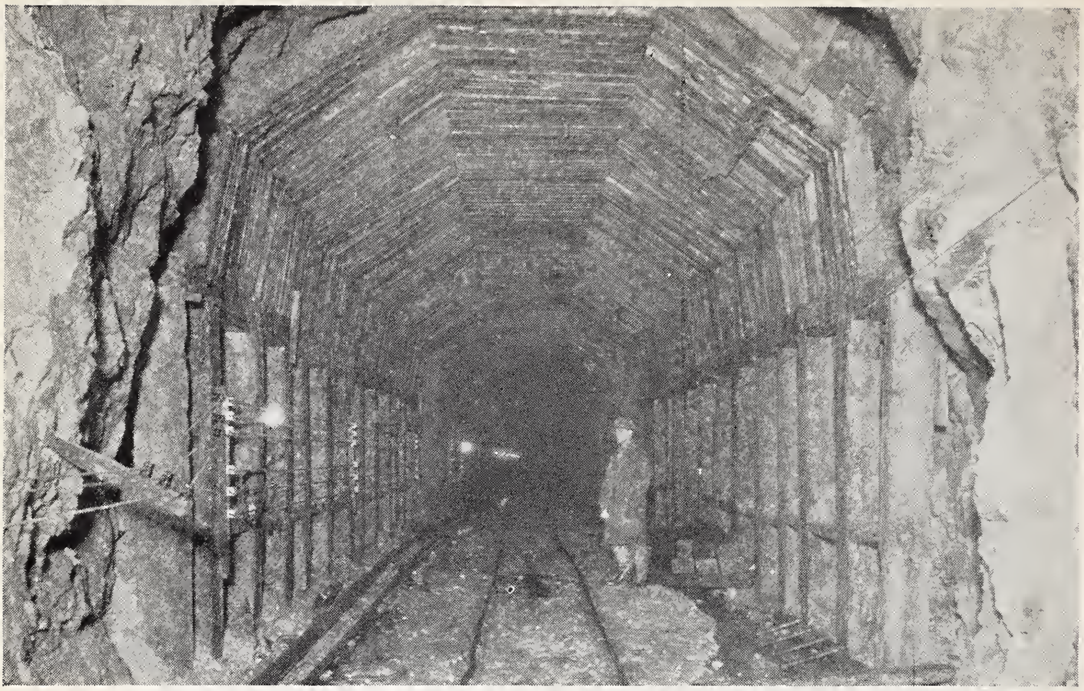


Plain Light.

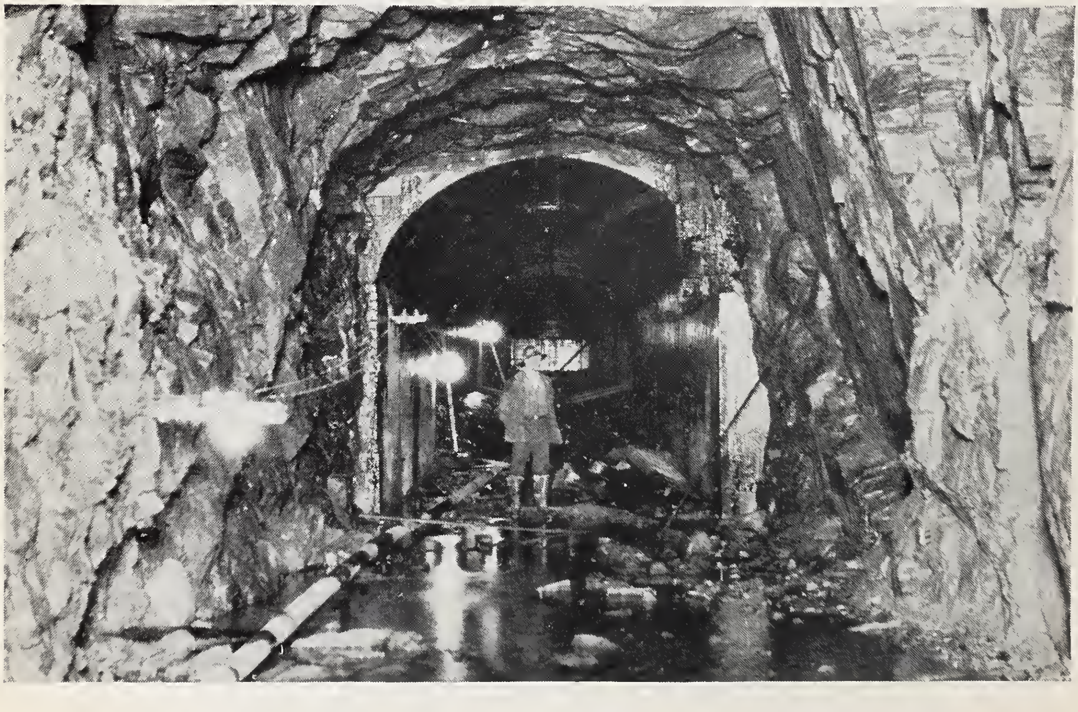
Polarized Light.

Photomicrographs of Paxton schist in plain and polarized light. The principal constituents are quartz (q), feldspar (f), and biotite mica (b), with titanite, magnetite, and apatite occurring as accessory minerals. The hornblende (h) and considerable portions of the feldspars, together with part of the quartz, are judged to have been introduced. The rock is a hybrid variety and is properly classed as an injection schist.

Magnification 30 ×



Permanent timber construction required to support crushed and altered rock in tunnel east of Shaft 9.



View of lined and unlined tunnel section. The rock breakage was typical of much of the tunnel.

gins of some crystals. Biotite and garnet crystals are often found embedded in a schistose groundmass made up chiefly of quartz and mica, of which about one-third of the mica content is biotite and two-thirds muscovite. There is also a small amount of albite feldspar. The larger crystals of biotite are oriented both parallel to and across the foliation or grain structure.

Numerous small lenses and bands of pegmatite and glassy quartz, as well as occasional broad vein-like pegmatite bodies, occur throughout the Boylston schist as seen in the tunnel, the quartz apparently being confined to zones of weakness, especially to shattered or crush zones. The pegmatite often contains white feldspar and glassy quartz. Quartz bands frequently contain garnet and are often associated with sulphide.

This formation was exposed in the tunnel for a distance of 1,685 feet between Stations 36+40 and 53+25. At the former location it is in conformable contact (Figure 8A) with the Oakdale quartzite, since the one grades into the other without any sharply defined boundary. The westerly limit is a sharply defined contact with a gneissoid granite, regarded as a part of the Fitchburg granite formation.

The Fitchburg Granite

The portion of the Fitchburg granite batholith occurring in a belt about 14,000 feet wide between Shafts 1 and 3 (Figures 8A and 8B) shows considerable variation in composition and structure. About 75 per cent of the rock is essentially a granite, the remaining portion being composed of extensive bodies of an older schist rock, now recognized as remnants of the former roof or cover.

The granite has a decidedly coarse texture and, due to orientation of mica flakes and frequently feldspar, it almost always exhibits a gneissoid or streaked structure. This structure is often accentuated by concentration of biotite mica in narrow bands which are generally parallel to the prevailing foliation. Sometimes the foliation appears crumpled or simulates swirls as if produced in flowage.

The mineral constituents within the granite proper vary in their proportions somewhat from place to place (Plate 4). This is particularly true of the micas, especially biotite, which is the most variable in amount. Orthoclase and microcline feldspars occur in abundance with lesser amounts of plagioclase feldspar of albite to andesine composition. Quartz and feldspar frequently occur in intergrowths. Titanite, apatite, and occasionally rutile are found as accessory minerals, and pyrite and titanite are frequently intergrown. In certain zones hornblende becomes prominent, although never dominant over biotite. The granite is essentially fresh and sound. Microscopically the rock preserves evidences of strain and shows slight fracturing.

Darker schistose portions, found mainly in the vicinity of Shaft 2, occur in several different forms; as narrow and broad bands in the granite, as irregular and sometimes sharply defined blocks, and as larger or more extensive bodies (Plate 10).

The granite frequently grades into schist through a zone that partakes of the characters of both (Plate 9). The foliation of the granite is always parallel or closely parallel to that of the schist. Throughout a large part of this granite belt the foliation structure is almost horizontal but there are zones of steeply inclined foliation especially in the easterly section where for about 4,000 feet the structure of the granite is almost vertical. At two other points farther west the structure is also very steep but there the rock is composed mainly of schist.

There is considerable variation shown in the composition of the schist bodies but in its simplest facies the rock might be classified as a quartz-biotite mica schist. Quartz and feldspar are always present in variable amounts together with the accessory minerals apatite, zircon, and titanite. Next in abundance to the quartz and feldspar constituents is biotite (often altered to chlorite), muscovite, little fibrolite, magnetite, zoisite, garnet, tourmaline, and sometimes epidote. The biotite mica is generally brownish in color in contrast to the black biotite of the granite. Whatever the rock may have been originally it is now thoroughly recrystallized. Some feldspars are partly altered to kaolin. Portions of the quartz and feldspar constituents, as well as pyrite, appear to have been introduced. Orthoclase, oligoclase and microcline feldspar, as well as biotite mica and granular quartz occur in large amounts and some of these at least have been introduced.

Pegmatite or coarse granite occurs extensively both in the schist portions and in the simple granite areas. It occurs as veins, lenses, and bodies of irregular outline, and grades into the surrounding rock through a transition zone having fewer pegmatite constituents. Pegmatite frequently occurs as a border between blocks of schist and the surrounding granitic mass. In the more schistose zones, pegmatite frequently occurs in the form of feldspar bunches, small lenses, streaks and bands. It is also commonly found as narrow veins following the course of ancient joint structures.

The mineralogy of the pegmatite is comparatively simple, the main constituents being a white microcline feldspar and quartz with variable amounts of biotite and muscovite mica. Black tourmaline, often in association with pyrite, is found developed occasionally to rather large crystals.

The Fitchburg granite extends for 7,100 feet west of Shaft 2 to Station 191+00, at which point it is in abrupt fault contact with the Brimfield schist. This contact is now determined to be approximately 1½ miles farther east than previously mapped.[1]

The Brimfield Schist and Brimfield-Ware Schist

This formation, designated in the easterly portion of the tunnel as the Brimfield schist and in the westerly portion, for reasons to be explained later, as the Brimfield-Ware schist, occurs in several places. Its most prominent occurrence in the easterly section (Figure 8B) is for a distance of 10,290 feet from its fault contact with the Fitchburg granite to Station 293+90, a point about 600 feet east of Shaft 4. This belt is part of the east limb of a broad anticlinal or domed structure and consequently the formation does not appear again until the west limb of the anticline brings it back into the tunnel (Figure 8D) about 2,600 feet west of Shaft 8. It continues from this point, at Station 746+00, as the major rock formation throughout both headings of Shaft 9 and the east heading of Shaft 10 (Plate 5) with but the two exceptions of the Coys Hill granite and a diabase dike. At Station 973+00 it is in contact with and appears to be overlaid by the Hardwick granite formation. The Brimfield-Ware schist outcrops again in the stretch of tunnel (Figure 8F) adjacent to Shaft 11 between Stations 1132+00 and 1188+60. A similar type occurs in the extreme westerly end of the tunnel to a point beyond the portal.

The Brimfield schist is chiefly a biotite mica schist (Plate 6). In places it grades into a biotite quartzite and in other places into a quartzite with very little mica. In the easterly section of the tunnel it contains only slight amounts of garnet but in the westerly section the garnet content is high and the rock in some sections could be correctly called a garnetiferous schist. A prominent feature is the general flaky appearance due to the abundance of biotite mica and to easy separation of the rock along the foliation lines. This characteristic is accentuated by numerous irregularities caused by small pegmatite lenses. In the easterly section of the tunnel the Brimfield schist is generally of a dark reddish-brown color, whereas in the westerly section it is darker and black. Both of these color variations are due chiefly to the mica content.

The rock is always foliated and commonly has a wavy and lenticular appearance due to small lenses of quartz of only a few millimeters in diameter. Accentuated by pegmatite and quartz streaks the foliation is deformed into small steep dipping folds.

The typical schist, unaffected by addition of igneous material, contains a great deal of reddish-brown platy and occasionally fibrous biotite mica with some muscovite mica. Quartz is present mainly in microscopic lenses. Larger lenses contain also oligoclase-andesine feldspar. Red garnet is commonly, but not always, present. Mention has already been made of the high garnet content in the rocks of the westerly section of the tunnel. The needle-like mineral sillimanite or fibrolite is abundant in some sections but absent in others, as is also graphite.

Variations of the typical schist occur in definite beds and layers parallel to the general foliation or bedding. Very hard and dense quartzite types are thus found. By an increase in quartz the biotite schist grades into a biotite quartzite and with decrease of the mica content into a true quartzite. The grain size is also variable but nearly always is less than 1 mm., the average being from 0.2 to 0.5 mm. Near the larger igneous bodies or injection zones the grains become larger.

---

[1] Emerson, B. K., op. cit., Geologic Map of Massachusetts and Rhode Island.

Certain varieties show complete recrystallization of the constituents and an intense foliation. Numerous large and small bodies of pegmatite and granite are present occurring both with sharply defined outlines and with transitional zones grading from one rock type into the other. These granite masses resemble in every detail the Fitchburg granite.

The Paxton Schist

The Paxton schist formation, consisting of three members, occurs throughout the central portion of the tunnel in a belt about 6 miles wide and in the vicinity of Shaft 8 in a narrower belt less than one-half mile wide. The upper member which immediately underlies the Brimfield schist of Shafts 3 and 4 extends in the tunnel (Figure 8B) for 16,530 feet between Stations 293+90 and 459+20, again (Figure 8C) for 1,080 feet between Stations 546+20 and 557+00 and again in the tunnel (Figure 8D) west of Shaft 8 for a distance of 1,000 feet between Stations 736+00 and 746+00. The lower member appears in three separated sections, from Station 476+30 to Station 522+00 for a distance of 4,570 feet, from Station 567+30 to Station 599+00 for a distance of 3,170 feet, and again from Station 722+75 to Station 731+20 for a distance of 845 feet. A middle member occurs between the upper and lower members and is considerably thinner than either of these.

The upper and lower members consist of a distinctly feldspathic quartz-biotite schist which is comparable to the Paxton quartz schist as recognized by Emerson. They are very similar in mineralogy, structure and other characteristics. The rock is commonly strongly foliated but also occurs in dense massive beds with very little foliation. In some cases the structure is made more evident by reason of a distinctly banded aspect (Plates 5, 7 and 8) produced by differences in the composition of the original sediment. A decrease in the quartz and feldspar content and consequent increase of mica creates a distinctly biotite mica variety. More massive and somewhat quartzose bands occur where there is an increase of quartz over the feldspar content. These bands are rarely over one inch thick and more often are only a fraction of an inch, especially those which are most strongly biotitic. Where there is an absence of banding the rock has a somewhat speckled appearance due to the distribution of biotite mica flakes in a groundmass of quartz and feldspar.

The most conspicuous structure indicating original sedimentary differences in composition is produced by a mineral aggregate which has a greenish-gray color, and which occurs in bands and thin lenses which average about half an inch in thickness but which may attain thicknesses of 3 or 4 inches. These are common and persistent and the metamorphic minerals of which they are now composed suggest a carbonate content in the original sediment.

The typical schist variety (Plate 11) consists chiefly of quartz, feldspar, and biotite with minor amounts of muscovite mica. The biotite is generally of a brownish or bronze color but is usually black when adjacent to pegmatite. The feldspar content is of variable grade ranging from oligoclase to labradorite but usually is of the andesine variety. In some sections numerous grains of carbonate occur as well as small amounts of garnet and zoisite.

In its general aspect the middle member of the Paxton schist resembles the Brimfield schist type. It is a distinctly more flaky biotite variety than the typical schist of the upper or lower members and as a whole contains considerably less quartz and feldspar. Despite the general resemblance to the Brimfield schist its structural association is perfectly clear and there is no doubt whatever of its designation as part of the Paxton formation as described here.

The Ware Schist

The Ware schist formation occurs in an anticlinal structure for a distance of 12,375 feet between Stations 599+00 and 722+75 (Figure 8D). It occupies the entire tunnel between Shafts 7 and 8 and extends for a considerable distance east of Shaft 7.

The general appearance of this rock is very similar to that of the Brimfield schist but it is separated from the Brimfield formation by the Paxton formation. The dominant rock type is a dark-brown flaky biotite mica schist containing very little quartz or feldspar but commonly containing garnet, at times in sufficient quantity to be called a garnetiferous biotite schist. Interstratified beds of considerably greater quartz content occur throughout the formation. Some relatively thin layers of more feldspathic schist are also present and these sometimes contain green bands similar to those occurring in the Paxton schist. Pegmatite and gneissoid granite make up a considerable portion of the formation (Plate 10). These occur as small and large lens-shaped bodies and masses of irregular shapes with either sharp or transitional contacts.

A rather unique difference between this formation and the Brimfield is the occurrence of limestone beds which vary from 6 inches to 15 feet in thickness. These beds, found on the west limb of the anticline, are of a greenish-gray color and exhibit a perfect banded structure which is largely due to differences in grain size.

The Coys Hill Granite

The Coys Hill granite is essentially a rather extensive and prominent occurrence of coarse granite within the Brimfield-Ware formation. It occurs as a conformable band or sill-like intrusion about 400 feet thick between Stations 937+00 and 946+00 (Figure 8E). Emerson[1] has mapped and described this rock type in some detail. The tunnel excavations failed to reveal anything new regarding its mineralogy and structure. There is one feature which might be emphasized however; that is the similarity of the Coys Hill granite to many other coarse granite types occurring in bands and lenses throughout the schist formations farther east.

The typical Coys Hill granite is a very coarse granite in which individual microcline feldspar crystals have developed to unusual size. These average from 1 to 2½ inches in diameter and frequently are even larger. The feldspars are so numerous and well developed in places that approximately 75 per cent of the rock is made up of large feldspar crystals or phenocrysts irregularly arranged in a darker and fine-grained groundmass of biotite mica schist. The schistose portion or groundmass, by reason of the addition of igneous constituents, is highly granitized but still exhibits a definitely streaked structure which conforms to the foliation of the over and underlying biotite schist. The coarse or porphyritic texture is due entirely to microcline feldspar, quartz being absent. Garnet, as well as fibrolite, occurs frequently throughout the rock.

The Hardwick Granite

The Hardwick granite is a conspicuous formation in the tunnel (Figures 8E and 8F) between Stations 973+00 and 1132+00. This formation is composed of several rock varieties ranging from granite to schist, the chief variety being a very dark foliated or streaked granite. This type is by far the most prominent part of the formation. It varies from a medium to coarse grain and is composed essentially of orthoclase and plagioclase feldspar and much biotite mica. The feldspars are generally present in excess of quartz. Other minerals often present are magnetite, apatite and zircon. Variations in the grain, internal structure, and mineral composition often occur which give the rock an appearance similar to a recrystallized biotite mica schist (Plate 6). Variations between schist and granite occur in the Hardwick formation which are similar to those occurring in the Fitchburg granite.

The foliation or grain structure as a whole is well developed, and is emphasized by the occurrence of light streaks and bands composed of a mineral composition consisting mainly of quartz and feldspar. In some stretches the intruded igneous rock was less affected by the older enclosing micaceous schist formation than in others. Through these stretches the rock has a decidedly massive or less foliated structure.

---

[1] Emerson, B. K., op. cit., pp. 240, 241.

Bands and injection zones of a light or gray granite, similar to the Fitchburg granite, which are best developed within the schistose portions, occur throughout the extent of the Hardwick formation. Small interconnected lenses of pink feldspar and glassy quartz occur, frequently resulting in giving a porphyritic aspect to the rock.

Schistose masses similar to the Brimfield schist type occur throughout the Hardwick formation. These are composed of a black mica schist in contrast to the brown mica schist formations farther east. Beds of a distinctly quartzitic schist also occur. The foliation structure of these members is prominent and regular, conforming to that of the surrounding rock. The contacts are conformable. In the lower and upper portions of the formation the typical rock is a fine to medium grained strongly foliated biotite schist containing considerable igneous material. The average variety consists of abundant black biotite mica, orthoclase and plagioclase feldspars, quartz and much garnet. The feldspars show considerable alteration to kaolin, and sericite is present. Variations in this type result from the addition of abundant apatite and the occurrence of orthoclase feldspar in greater amount than quartz. Fibrolite and graphite are often present in these schists, whereas they are always absent in the more granitic types. Thin beds of a quartzitic schist containing abundant recrystallized quartz and some plagioclase feldspar occur within the more micaceous schist types. A particular feature of the quartzitic schist is the presence of graphite and tremolite and large sprawling garnets.

The Monson Granodiorite

The Monson granodiorite occupies most of the tunnel (Figure 8F) between Shafts 11 and 12 and a large part of the Swift River Valley lying a short distance westerly. In the tunnel its exact limits are from Station 1188+60 to Station 1307+75. The typical rock (Plate 7) is a grayish foliated granite, although in some sections it is quite massive. The foliation structure is due to the concentration of biotite in streaks and narrow bands. Beds and bands of hornblende diorite, which in the majority of cases are oriented parallel to the foliation, also occur throughout its extent. In a few cases these exhibit irregular structures in which the bands have been faulted and folded.

The granodiorite of the tunnel (Plate 9) is an igneous rock of rather simple composition. It chiefly contains orthoclase and plagioclase feldspars, quartz, a little biotite mica, and considerable hornblende and magnetite. Slight amounts of garnet and sericite are also present. In some stretches schistose bands are very numerous and become the dominant feature of the rock. Light and dark colored bands are thus seen which are the result of variations in concentration of igneous constituents, the general appearance being that of an injection gneiss. The schist portions are essentially unreplaced remnants of the former cover and to all appearances are related to the Brimfield-Ware formation (Plate 8).

The dioritic rocks are made up largely of abundant hornblende, considerable plagioclase feldspar, and minor amounts of magnetite, biotite, titanite and apatite. The rock is frequently of a massive structure, especially where it forms a contact zone between the Monson granodiorite and the Brimfield-Ware schist formation. Emerson[1] has called this particular variety the Dana diorite.

A pale reddish or pink variety of granite intrudes the gray Monson granodiorite at several points. The best example of this occurs as a sill-like body or sheet east of Shaft 12. The outer portions of this body are of medium to coarse grain. The adjacent wall rock is peculiarly spotted by reason of the scattered reddish orthoclase feldspar crystals in the gray granite. The inner portions of this intrusive mass are of much coarser grain than the outer, some feldspar crystals being several inches in diameter. The whole rock has undergone transformation in which the feldspars have been greatly altered to a clayey constitution and partly replaced by quartz. Upon excavation this material was seen to be composed of gray to reddish clay surrounding angular blocks of quartz. When exposed to the elements the unreplaced but completely altered feldspars in these blocks were easily weathered and the clayey material washed away. Because of the instability of this rock it was necessary to support the tunnel roof and sides by erecting timbering and providing for greater thickness of concrete lining. The phenomenon presented here is similar to the Lantern Hill quartz replacement in southeastern Connecticut described by Loughlin.[1]

---

[1] Emerson, B. K., op. cit., p. 244.

A large remnant mass of schist approximately one-half mile wide divides the Monson formation into two parts. The rock is a medium-grained strongly foliated biotite schist frequently containing small beds of amphibolite schist. The average schist contains much biotite mica as well as acid plagioclase and quartz. Garnet, titanite and apatite minerals are also present. Streaks and bands of feldspar-quartz composition are as prominent here as in the schist formations elsewhere.

Diabase

Tunnel excavations were carried through two diabase or trap rock dikes, one of which occurs between Shafts 3 and 4 (Figure 8B) and the other between Shafts 8 and 9 (Figure 8D). These dikes, which have been traced for several miles beyond the immediate vicinity of the tunnel, cut across the area in a nearly parallel northeasterly direction. They are offshoots of the much larger diabasic intrusions of Triassic age occurring within the Connecticut Valley area.

The Mixed or Hybrid Rocks

The formations of the tunnel area seldom occur in a simple condition. They vary from true schists, derived by the metamorphism of sediments, to gneissoid granites and pegmatites, clearly of igneous origin. Traces of material, more or less clearly defined, and resembling the original schists are nearly always associated with the granitoid masses. As a matter of fact, between the two extremes of granite and schist there are all gradations which appear to be mixtures of these two primary types.

Examination and critical inspection of these formations in the tunnel suggests their classification as mixed or hybrid rocks. The field relations of the different original sedimentary formations were surely favorable for the invasion of granitic and pegmatitic juices from an igneous body encroaching upon them from below. If it were ever possible for igneous material to penetrate rocks of a schist type it should have happened under these conditions. Originally there were extensive bodies of sediments developed into schists with a strong foliated structure in which penetrating solutions could find many weaknesses along which to move in attempting to escape or break through. Such a process, involving a highly penetrative invading solution, ought to produce all of the varieties of structure and proportions between simple schist on the one hand and true granite or pegmatite on the other. This is exactly what is found in the tunnel and there appears to be no other way of accounting for them.

The main bodies of the Fitchburg granite and the Monson granodiorite contributed a large part of the invading solutions. All of the formations of metamorphic character developed antecedent to the igneous invasion have been affected to some degree dependent upon their distance from the igneous sources of supply and on their differences in primary composition and metamorphic structure.

The deformations existing at the time of the igneous intrusion appear to have determined the results and to some extent to have directed the major movements. It should have been possible for the granitic juices or magma to penetrate readily along clear-cut fractures or fissures developed by deformations, thus forming the larger dikes and other transecting masses of simple composition. The more intimate mixtures of constituents, characteristic of both the schists and the granites could not have been produced without actual mixing of the two types of rock in some manner or the replacement of a portion of one by a portion of the other.

The mixed product which occurs in one form or another throughout long stretches of the Quabbin Aqueduct, presents many facies and every possible proportion. The introduced igneous material is so intimately interspersed and interlocked with the recrystallized sediments that it is quite impossible to distinguish clearly between them and to determine their relative proportions. It is, however, usually possible to identify the two major elements of the mixture. The common facies is, therefore, a hybrid rock that is properly called an injection schist.

---

[1] Loughlin, G. F., The Gabbros and Associated Rocks at Preston, Conn., U. S. G. S. Bulletin 492, 912.

The clearly recognizable igneous bodies occurring in these schists are found in several modes of occurrence and with wide range in size as follows: feldspar bunches, knots, or lenses which often consist of single crystals or a simple aggregate of feldspar crystals; thin lenses and bands of pegmatite producing a typical banded injection structure. There is sometimes associated with this type an intimate intermixing with the schist; large lenticular bodies of pegmatite varying in size from a few inches to several feet in diameter; sill or sheet-like bodies which often attain sizes as great as 50 feet or more in thickness; irregular but generally lenticular-shaped bodies containing pegmatite and gneissoid granite.

The contacts between these igneous bodies and the older schist members are either sharply defined or gradational from one type to the other. On a large scale the foliation of the schist is bent around the igneous bodies indicating that at least a part of the space required for the intrusive pegmatite was made by actual displacement of the schist. Embayed contacts, however, and truncation of the foliation structures indicate that the larger part of the space required was made by replacement of the schist. Gneissoid granite grades into the schist through a zone of mixing and banded injection as if the granitic solutions had soaked into the surrounding schist and penetrated almost every interstitial weakness.

Pegmatite is often uniformly distributed along the foliation planes of the biotite schist but its concentration varies greatly from place to place, the greatest concentrations being found in the biotite schist formations. In the Ware schist formation, for example, for a distance of 1,000 feet between Shafts 7 and 8, there occurs gneissoid granite which is certainly almost wholly igneous, and for a considerably longer stretch the amount of injection is very heavy (Plate 10). The concentration of pegmatite within the Paxton schist is considerably less than in the more micaceous varieties (Plate 7). In the more quartzose schist members the amount of pegmatite is negligible, although the beds are cut by quartz veins.

The principal constituents of the most widespread pegmatite, responsible for the development of mixed and hybrid rocks, are microcline and quartz. This pegmatite is always white, while the less notable pegmatite, more abundantly developed in the Hardwick and Monson granites, is of a reddish color. Albite and oligoclase feldspar are present in variable proportions. The plagioclase feldspars are often partially altered but microcline feldspar is nearly always clear and fresh. In the larger bodies feldspar is considerably more abundant than quartz but in the narrow bands and lenses, especially in the end sections of elongate lenses, the main constituent is glassy quartz. Both muscovite and biotite mica are generally present as accessory minerals. Garnet is prominent in the pegmatites occurring within the distinctly garnetiferous schists. Black tourmaline is common throughout the Paxton schist of Shafts 4 and 5. Other variations in composition are due to the presence of schist inclusions and to concentration of biotite in streaks parallel to the foliation. Sericite, together with chlorite, is an abundant alteration mineral. Large sections of granite are strikingly fresh with almost no evidence of alteration, whereas the dusty appearance of orthoclase and plagioclase feldspars in contrast with the freshness of the microcline feldspar is very noticeable. Large grains occasionally show granulation along their margins and the softer minerals, chiefly mica, have developed along the weaknesses. Garnet is often present in large amounts and is believed to indicate assimilation of some other rock.

Portions of the gneisoid granites represented within the injection schists possibly are not all of the same origin. It is believed, however, that a large portion of the streaked rocks had their origin through a process of extreme granitization of the overlying and adjacent schist.

Granitization of Schist Bodies

The presence and mode of occurrence within the tunnel area of numerous and extensive bodies of schist mapped as Fitchburg granite raises the question of origin of the granite itself. Was it formed, as most granites are believed to have been, by simple crystallization of an igneous material or magma, or is it, instead, a mixed and variable product made up in part of simple introduced or eruptive magma and in part of absorbed masses of older rock? The mode of occurrence of these schist bodies seems to have a bearing on this question. These masses are so uniform in orientation and their internal structure matches so well that they give the very definite impression of having been but little disturbed. As previously stated, most of the contacts are gradational in character and the foliation structure of the granite is essentially continuous and consistent with that of the nearby schist bodies.

A close genetic relation is indicated between the streaked structure of the granite mass and the foliation structure of the schist, which suggests that the structure seen in the granite may have been inherited from the schist. This could happen if a mass of schist were so thoroughly granitized that more than three-fourths of its volume was composed of granitic constituents. It could happen also if a schist body were digested and absorbed by an invading granite without complete redistribution of the constituent elements. In this case the micas would still remain in part in the same general structural relation. Both processes are believed to have operated in some of this material and caused the streakedness within the granite.

A large portion of the Fitchburg granite preserves, somewhat crudely to be sure, the structure of the schist which originally occupied the same place. In other words, the foliation in the granite is chiefly an inherited structure which marks the major structure lines of the schist masses that were invaded, absorbed and replaced (Plate 10). It is realized, of course, that some of the streaked structure is probably due to movement of the granite mass after crystallization had begun, although these movements seem to have followed the chief lines of deformation in the invaded rock series.

The general deformation of the region, preceding the granite invasion, may be worked out from these inherited structures. A study of the field occurrence of the two rock types, schist and granite, together with their structure, mineralogy and gradational features, suggests several stages in the formation of the granite which are here summarized.

Before the invasion of the granite the geologic column was represented by a thick series of rocks consisting partly of the Brimfield-Paxton-Ware series. Deformation of these sediments was accompanied by, or closely followed by, encroachment of a large granitic body. Advance of the highly fluid granitic magma or rock solution was greatly facilitated by certain zones of weakness developed by this deformation, especially in the area between Shafts 1 and 2, where there is preserved even now a strong vertical or down-folding in the granitic structure. It is here that granitic soaking and injection was most intense as indicated by either displacement or complete granitization of the original rock. Facilitating this process was the breaking, from the lower members of the rock series, of blocks which foundered and were more or less completely absorbed in the granitic magma. This process, accompanying continued down-folding and faulting, created the main channel for encroachment of the granite magma. Further extension of the invasion was accomplished largely by lateral penetration and soaking. Numerous smaller feeders from below distributed over a large area must have added greatly to the supply of magma.

Small openings and potential weaknesses in the strongly foliated rock provided sufficient space for the highly fluid feldspathic magma which worked its way into the schist both by this means and by a gradual process of replacement. Thus there were developed multitudes of small feldspar and quartz lenses as well as thin streamers made up of mineral aggregates of the same composition, all of which have been described in more detail elsewhere in this report.

In the earlier stages the biotitic aspect of the rock was dominant over the feldspathic and the appearance must have been similar to a banded or injection schist or gneiss. Further injection and soaking increased the igneous content until these constituents were dominant over those of the original schist. This theory is supported by the occurrence within the granite of schist exhibiting essentially all of these features. Remnants of the schist can be seen accurately oriented and unreplaced grading into completely granitized rock with only traces of the same orientation.

In a more advanced stage the rock was completely granitized and appeared as a slightly foliated and sometimes even massive biotite-muscovite mica granite. It is possible also that large portions of the present granite masses originated from direct crystallization of the invading magma, but granitization of the older rock is believed to account for equally large proportions.

The less extensively granitized and injected bodies of schist associated with the granite represent the more dense and massive beds such as the quartzitic varieties interbedded with the original biotite schist. The pore space in such rock was comparatively small, and beds of this massive type yielded very little during deformation, so that slight opportunity was provided for the granitic juices to work their way into these portions.

Structural Features

A great variety of internal structures are exhibited by the rocks. Some of these structures are due to igneous injection and have been described elsewhere in this report. Others, such as bedding and sedimentation lines, are original. Still others are of metamorphic origin and raise questions as to the conditions and processes that could have produced them. Of these structures the most characteristic is that of foliation, which is developed throughout the schists and a large part of the granite formations.

Foliation and Bedding

In the construction of a geologic section to show the relation of the formations penetrated by the tunnel special attention was paid to all structural features which might have a bearing on the relation of foliation to original bedding. The close parallelism found to exist between original bedding or sedimentation lines and the present foliation must be the result of subsequent metamorphism. This conclusion has also been reached by others[1] who are familiar with the formations in central Massachusetts and their counterparts in eastern Connecticut.

The bedding planes of the small but distinguishable interbedded layers, composed of different mineral quality, are parallel to the present foliation structure of the schists. This is true of the micaceous and quartzitic beds in the Brimfield, Ware and Brimfield-Ware formations, of the limestone beds in the Ware schist, and the garnetiferous beds in the Brimfield-Ware schist and of the thin micaceous and calcareous layers and streaks in the Paxton formation. A graphical check of the general conformity of the bedding and foliation structure, obtained by plotting the inclination of the foliation lines as if they were true bedding planes, showed a general conformity between the boundaries of the several formations and the expected general structure.

In the recrystallization of such great bodies of schist it is rather striking that the foliation structure should conform so closely to the original bedding of the sediments from which they were made. This is surprising because of the flat-lying attitude of these formations throughout long stretches of the tunnel. It is difficult to see how this condition could have resulted if recrystallization of the schists were due chiefly to intense metamorphism resulting from the strains induced by deformation. The gentle folding of the whole rock series over extensive areas could have accounted for only a small amount of differential internal movement. The recrystallization of the schists is believed to have been caused more by the metamorphic action of subjacent and invading igneous bodies, than by metamorphism resulting from movement or regional deformation.

---

[1] Callaghan, E. C., A Contribution to the Structural Geology of Central Massachusetts, Annals of the New York Academy of Science, Vol. 33, pp. 43–46.

Rice, Wm. North, and Gregory, Herbert E., Manual of the Geology of Connecticut, State of Connecticut, Geological and Natural History Survey, Bulletin No. 6.

Loughlin, G. F., The Gabbros and Associated Rocks at Preston, Connecticut, U. S. G. S. Bulletin 492, 1912, pp. 24–25.

Thickness of Formations

Data pertaining to the measurement of formations is of interest to both the geologist and the engineer. To the geologist such information is essential to the grouping of rocks into formational units and to an understanding of the geology of a region. The solution of problems pertaining to correlation of the formations in one area with those in another, and to the interpretation of the deformation and structure of formations is also partly dependent upon such data. In a glaciated region, such as central Massachusetts, underlaid by metamorphosed igneous and sedimentary rocks, it is often difficult to obtain even an approximate estimate of the formational thicknesses.

The excavations exposed several formational contacts which were located accurately, thus defining the extent of the rock formations in the tunnel, and, by construction of the geologic section shown in Figure 8, the thicknesses of the several formations were estimated. The estimates of the Paxton formation are considered to be particularly reliable as all four contacts of the three members were located. Inaccuracies in estimates of this kind may be due to several causes, chief of which is the uncertainty of the amount of increase or decrease in the thickness of strata resulting from folding and faulting.

A significant feature of the geologic section is the marked decrease in thickness of the Paxton formation from east to west. The fact that the Paxton schist was not again recognized in the tunnel for the remaining eleven miles is not surprising as the great amount of igneous injection in several stretches farther west, especially in that of the Coys Hill granite, could have changed the appearance of the formation beyond recognition. In this connection it is of interest to note that Emerson[1] considers the Quabbin quartzite, outcropping farther west in the Swift River Valley, as the equivalent of the Paxton schist.

The term "apparent thickness" in the tabulation of thickness of formations shown below means the thickness of the formations from one formational boundary to another. This measurement does not take into account variations produced by folding and faulting. By "actual thickness" is meant the estimated extent of the original formation when its deposition as a sediment was completed.

Lateral Extent and Estimated Thickness of Formations

Formation	East Contact Station	West Contact Station	Length Exposed in Tunnel Lin. Ft.	Apparent Thickness in Tunnel Ft. (Approx.)	Actual Thickness Ft. (Approx.)	Remarks
Worcester phyllite	—	—	0	—	1,600	Not exposed in tunnel.
Oakdale quartzite	—	36+40	1,542	800	1,800	Not fully exposed in tunnel.
Boylston schist	36+40	53+25	1,685	800	—	Truncated by Fitchburg granite formation.
Fitchburg granite	53+25	191+00	13,775	—	—	
Brimfield schist	191+00	293+90	10,290	2,000	Less than 3,000	Fault contact with Fitchburg granite at Sta. 191+00.
Paxton schist (upper member)	293+90	459+20	16,530	1,100	1,100	
Paxton schist (middle member)	459+20	476+30	1,710	400	400	
Paxton schist (lower member)	476+30	522+00	4,570	—	—	Lower contact not exposed.
Paxton schist (middle member)	522+00	546+20	2,420	400	400	
Paxton schist (upper member)	546+20	557+00	1,080	—	—	Upper contact not exposed.
Paxton schist (middle member)	557+00	567+30	1,030	400	400	
Paxton schist (lower member)	567+30	599+00	3,170	1,100	1,100	

---

[1] Emerson, B. K., op. cit., p. 72.

Lateral Extent and Estimated Thickness of Formations — Continued

Formation	East Contact Station	West Contact Station	Length Exposed in Tunnel Lin. Ft.	Apparent Thickness in Tunnel Ft. (Approx.)	Actual Thickness Ft. (Approx.)	Remarks
Ware schist	599 +00	722 +75	12,375	3,000	Less than 3,000	Contains many igneous masses.
Paxton schist (lower member)	722 +75	731 +20	845	450	450	
Paxton schist (middle member)	731 +20	736 +00	480	175	175	
Paxton schist (upper member)	736 +00	746 +00	1,000	290	290	
*Brimfield-Ware schist	746 +00	937 +00	19,100	5,100	—	
*Coys Hill granite	937 +00	946 +00	900	400	—	
*Brimfield-Ware schist	946 +00	973 +00	2,700	900	—	
*Hardwick granite gneiss	973 +00	1,132 +00	15,900	4,000	—	
*Brimfield-Ware schist	1,132 +00	1,188 +60	5,660	3,100	—	
*Monson granodiorite	1,188 +60	1,307 +75	11,915	7,500	—	
*Brimfield-Ware schist	1,307 +75	2,800 ± ft. west of portal	—	2,600	—	

* Actual thickness not estimated because of possible repetition of strata resulting from folding and faulting.

Folds and Faults

The geologic structure over long stretches is comparatively flat and strikingly little folded for such intensely metamorphosed schists. The most pronounced deformations occur in the Fitchburg granite belt and in the westerly portion of the tunnel. As stated previously, the foliation structures of the granitic rocks are inherited from the older schists which were invaded by granite.

It is rather remarkable that so little major faulting was recognized in the belt crossed by the tunnel. Many minor structures indicate that there has been faulting and it is certain that the district has been considerably deformed, but ordinary evidences of faulting have been obscured or entirely obliterated by igneous intrusions. It is believed that where faulting has taken place the displacements in most cases were relatively small, and, in the easterly section of the tunnel, at least, were insufficient to displace an entire formation. This contention may not hold, however, for the westerly portion of the tunnel.

In order to reconcile the distribution of the middle member of the Paxton schist it was necessary to place two faults in the geologic section east of Shaft 8, one of which was located in a break that is now occupied by a rather large intrusion of pegmatite. This location was indicated by slight differences in the character of the rock on either side of the pegmatite. The second fault was located nearer the shaft at a point where shear structures and inclination of the strata gave evidence of faulting. Both of these faults are of slight displacement and are virtually negligible as structural features.

As noted previously, the contact of the Fitchburg granite with the Brimfield schist east of Shaft 3 is abrupt and sharply defined. On the east side of a shear and crush zone the normal granite occurs together with granitized schist, and on the west the Brimfield schist occurs with only small amounts of igneous injection. Within the crush zone there are several narrow quartz veins carrying structural evidence of normal fault movement in which the west, or Brimfield schist side, has been displaced downward. Here again the amount of displacement is judged to be comparatively small.

Estimates of the actual thickness of the formations west of Shaft 8 have not been submitted because of the uncertainty in regard to folding and faulting. Difficulties arise in the separation and assignment to their formations of several biotite schist strata, which occur throughout the tunnel between Shafts 9 and 12, because of their similarity to each other and to the Brimfield and Ware schist formations farther east. Consequently, the name Brimfield-Ware schist has been applied to these doubtful formations. Emerson assigned these schists to the Brimfield formation but it may be noted that he was not aware of an additional biotite schist formation designated as the Ware schist. The schists east of Shaft 10 and in the vicinity of Shaft 11 are of a higher garnet content and darker color than the less garnetiferous brown Brimfield schist east of Shaft 4 and between Shafts 8 and 9. Because of their garnet content the garnetiferous schists of the Ware-Brimfield formation are believed to be more closely related to the Ware formation than to the Brimfield formation.

The continuous westerly dip of the foliation between Shaft 8 and the portal may be due to closed or isoclinal folds overturned toward the east. The westerly dip of the foliation structure of schist strata within the Hardwick granite and Monson granodiorite is not at variance with this interpretation as the structure in these formations has been inherited in much the same manner as in the Fitchburg granite. Some of the streaked structure in these rocks may be due to movement of the igneous mass during and after crystallization, but these movements followed the chief lines of deformation in the invaded rock series.

The geologic section through the metamorphosed sediments, west of the main body of Wachusett Reservoir and east of the Stillwater River, where the structure is too plain and simple to be questioned, shows a simple anticlinal and synclinal structure in which a phyllite conformably overlies a phyllitic quartzite. This relation was found long ago by Emerson and Perry,[1] who mapped the phyllite as the Worcester phyllite and the phyllitic quartzite as the Sterling quartzite, which was later named Oakdale quartzite by Emerson. Completion of the section between the Stillwater River and Shaft 2 involves several possible interpretations of the geologic structure, a discussion of which follows.

Age and Formational Relations

An understanding of the structural and metamorphic relations of the Worcester phyllite and Oakdale quartzite, as recognized by Emerson, to the schists in the areas farther west requires a review of the discussions pertaining to the age relations and genesis of these rocks as given by previous workers in this field. Emerson and Perry,[2] with the cooperation of David White, have established the age of the Worcester phyllite at its type locality, the Worcester "Coal Mine," as Carboniferous, and because of its conformable relation with the Oakdale quartzite, they have concluded that the quartzite also belongs to the Carboniferous. Emerson[3] states that "The Worcester phyllite is Carboniferous, for it contains Lepidodendron and several species of ferns at the Worcester 'coal mine.' . . . The Oakdale grades into the overlying Worcester phyllite by an easy transition, without visible unconformity or interruption. . . . The conclusion that the Oakdale quartzite is of Carboniferous age is greatly strengthened by the fact that it and the Worcester phyllite are closely folded together. . . . Another reason for believing that the two formations belong to the same geologic period is that they are cut by the same set of igneous rocks."

Emerson considers that the Brimfield and Paxton schists are also of Carboniferous age and contends that the former is simply the metamorphic equivalent of the Worcester phyllite, the Boylston schist being an intermediate type between the Worcester and the Brimfield, and that the Paxton is a metamorphic equivalent of the Oakdale quartzite. He further states[4] "The reason for extending the Carboniferous area to include the highly altered rocks that are correlated with the Oakdale and Worcester is that, even though those rocks are much more metamorphosed, every effort to find boundaries separating them from the less altered rocks of undisputed Carboniferous age in the Worcester area has failed. . .

". . . not only does the great increase of granite northeastward and westward from the Worcester area furnish a sufficient explanation for the increased metamorphism of the sedimentary rocks, but also the metamorphism is just the sort that such granite should produce. . . ." It is now intended to test this opinion in the light of new and more complete geologic information obtained by study of the rock formations penetrated by the Quabbin Aqueduct. The chief elements involved will be given in the form of alternative interpretations of the structural attitude of the formations. The first three of these have already been presented by Callaghan.[1]

---

[1] Perry, J. H., and Emerson, B. K., The Geology of Worcester, Mass., 1903, p. 43.
[2] Perry, J. H., and Emerson, B. K., op. cit., p. 29.
[3] Emerson, B. K., op. cit., p. 77.
[4] Emerson, B. K., op. cit., pp. 77–78.

Interpretation I — Based on Emerson's Conception of Equivalence of Formations

Assumptions — Simple Structural Relation

All of Carboniferous Age

Brimfield Schist = Boylston Schist = Boylston Schist
Upper Paxton Schist = Phyllitic Quartzite = Phyllitic Quartzite
Middle Paxton Schist = Phyllite = Worcester Phyllite
Lower Paxton Schist = Quartzite = Oakdale Quartzite
Ware Schist = ? = ?

This interpretation is based on Emerson's view that the Paxton and Brimfield schists are metamorphic equivalents of the Carboniferous Oakdale quartzite and Worcester phyllite, and that the simple types of the Worcester strata grade into the more complex metamorphic types of the areas to the west. Emerson was not aware of the fact, which has now been established, that the schists west of the Worcester strata occur in more than two formations, that the Paxton schist is composed of three members, and that the Brimfield type occurs in two thick formations, called here the Brimfield schist and the Ware schist. Figure 9 shows the geologic section based on this hypothesis of equivalence of formations. In the section the phyllite, or presumed Worcester phyllite, is shown as grading into the middle member of the Paxton schist, and the quartzite, or presumed Oakdale quartzite, as grading into the lower member of the Paxton schist.

The Brimfield schist of Shaft 3 is carried through the granite area of Shaft 2, the foliation of the latter being considered as inherited from the original structure of the schist. The Boylston schist is correlated, then, with the lower part of the Brimfield.

Although this is one of the simplest explanations, there are difficulties in its acceptence at full face value, just as there are in all of the simpler explanations assuming equivalence of the two sets of formations. It should be stated that this structural interpretation, with the single exception of the equivalence of formations, does not conform to the ideas of Emerson and Perry, who concluded that the structural relations of the rocks are more nearly like those presented in Interpretation III, shown graphically in Figure 11. The great resemblance, in some respects, of the schists to more ancient rocks has led to consideration of alternative hypotheses given as the last three of the group.

Interpretation II — Based Partly on Emerson's Conception of Equivalence of Formations

Assumptions — Repetition of Strata by Faulting

All of Carboniferous Age

Brimfield Schist = Boylston Schist = Worcester Phyllite
Upper Paxton Schist = Phyllitic Quartzite = Oakdale Quartzite
Middle Paxton Schist = ? = ?
Lower Paxton Schist = ? = ?
Ware Schist = ? = ?

This interpretation is based partly on the premises of the previous one, that the schists of the tunnel are the metamorphic equivalents of the Carboniferous Worcester phyllite and Oakdale quartzite. The distribution of rock types, as revealed from surface exposures, indicates a narrow strip of phyllite between the quartzite of the anticline and the phyllitic quartzite of the tunnel adjacent to Shaft 1. This repetition of strata, as indicated in Figure 10, could be brought about by a normal fault in the valleys now occupied by the upper part of the reservoir, Stillwater River and Malden Brook.

Interpretation III — Based Partly on the Conception of Emerson and Perry of the Equivalence of Formations

Assumptions — Repetition of Strata by Folding

All of Carboniferous Age

Brimfield Schist = Boylston Schist = Worcester Phyllite
Upper Paxton Schist = Phyllitic Quartzite = Oakdale Quartzite
Middle Paxton Schist = ? = ?
Lower Paxton Schist = ? = ?
Ware Schist = ? = ?

This interpretation is based upon the conceptions of Perry and Emerson[2] that the Brimfield and Paxton schists are metamorphic equivalents of the Carboniferous Worcester phyllite and Oakdale quartzite, and also that, west of the Oakdale arch or anticline, these strata occur together in closed and partly overturned folds. A development of the structure from this premise would correlate, therefore, the Worcester phyllite with the Boylston and Brimfield schists, and the Oakdale quartzite with the phyllitic quartzite of the tunnel and the upper Paxton member. Such an interpretation would mean that the narrow strip of phyllite on the west limb of the anticline is an intensely squeezed portion or syncline of the Worcester phyllite. Minor folds and fault structures within the phyllite and quartzite indicate a thrust action from the west. This is further indicated by the minute folding and crumpling of the phyllite and by the minor overthrust relations found at a few points in exposures located along the north shore of the Wachusett Reservoir.

---

[1] Callaghan, E., op. cit., p. 70.

[2] Perry, J. H., and Emerson, B. K., Geology of Worcester, 1903, pp. 148–149.

This alternative interpretation, shown in Figure 11, and originally presented by Emerson and Perry, appears to satisfy the structural requirements as fully as any, if the basic assumptions of geologic age and correlation of formations are correct.

Dissenting Views Concerning Geologic Age and Genesis of the Schists

Geologists, who have studied the geology of this area in the field, are not in agreement as to the age relations of the uncertain schists and the proven Carboniferous phyllite. East of the Worcester sediments there occurs a belt of injection gneisses and schists containing masses of Paxton and Brimfield schist and composing a formation referred to by Emerson as the Bolton gneiss. Regarding the principal parts of this formation he states[1] "... the Oakdale quartzite and Worcester phyllite formerly extended eastward over the area . . . the 'Bolton' gneiss and associated rocks as a whole . . . represent those formations, folded and partly metamorphosed to the Paxton and Brimfield schists, and . . . form the cover, now greatly eroded, . . . into the lower part of which the Andover granite was intruded.

". . . therefore, the whole complex . . . (except, possibly, a few small included masses of limestone) . . . is of Carboniferous age.

"Messrs. Keith and LaForge, on the other hand, have come to a radically different conclusion. . . . They agree . . . in believing the Andover and Ayer granites to be of late Carboniferous or post-Carboniferous age, . . . and in the view that the 'Bolton' gneiss represents a folded cover . . . into which the Andover granite was intruded, and that the intrusion was in part contemporaneous with the latest folding of the rocks.

"They doubt, however, that the Worcester phyllite and Oakdale quartzite ever extended eastward to any great distance over the area occupied by the gneisses . . . that the chemical and mineral composition of the 'Bolton' gneiss is sufficient evidence to warrant the conclusion that it was derived from a rock like the Brimfield schist; and that the Paxton schist, or at least a great part of the rock so mapped, was ever derived from the Oakdale quartzite by any kind of metamorphism. . . .

"They believe that the sedimentary part of the unnamed gneisses and schists is very much older than Carboniferous and probably pre-Cambrian; that the much deformed and sheared associated igneous rocks . . . are very much older than the Andover and Ayer granites and are also probably pre-Cambrian; and that the whole complex was first folded . . . probably in pre-Cambrian time, at any rate long before the deposition of the Carboniferous strata or the intrusion of the younger granites.

"The principal facts . . . on which they base their conclusions as to the age of the rocks are as follows: the strong resemblance . . . of some of the . . . schists to rocks in other parts of the State which are generally admitted to be probably pre-Cambrian; the greater deformation, greater alteration . . . and the general appearance of greater age of the sedimentary schists as compared with strata that are undoubtedly Carboniferous . . . and the fact that a great part of the deformation and alteration of the . . . gneisses and schists appears to antedate the deposition of the Carboniferous strata and the intrusion of the younger granites."

---

[1] Emerson, B. K., op. cit., pp. 86–89.

The evidence indicates that the schist formations of the tunnel represent the metamorphic facies of an ancient series of sedimentary rocks, and that, after a long interval of time, the Carboniferous strata were unconformably laid down upon them. This view is in agreement with Messrs. Keith and LaForge. Conclusive proof of any particular theory is lacking. When the Quabbin project was begun it was thought that construction of the tunnel would surely solve this geologic riddle for it transects the disputed zone where one rock series was supposed to change into the other. Unfortunately, despite the fact that this ground was laid open to view and was subjected to inspection inch by inch for many miles, the case is still a subject for interpretation rather than direct observational proof, principally because the Fitchburg granite has invaded the critical zone where such a change would have taken place and appears to have destroyed the evidence.

INTERPRETATIONS IV AND V — BASED ON CONCEPTION OF DIFFERENT AGES

Assumptions — Different Ages, Thrust Faulting and Igneous Invasion

* * * * * * *	=	Igneous invasion (Fitchburg granite)	Late Carboniferous Age
# # # # # # #	=	Overthrust fault	
Worcester phyllite	=	Boylston schist	Carboniferous Age
Oakdale quartzite	=	Phyllitic quartzite	
– – – – – – –	=	Unconformity	
Brimfield schist	=	?	Pre-Carboniferous Age
Paxton schist	=	?	
Ware schist	=	?	

These two interpretations assume that the Paxton, Brimfield and Ware schist formations represent an ancient series of rocks which were somewhat metamorphosed and deformed before the much younger Carboniferous strata were laid down. These younger rocks were unconformably deposited on an eroded surface which cannot now be traced. The whole double series of formations was then folded and faulted after which the Fitchburg granite invaded the deformed rocks and destroyed most of the structural evidence of these steps. In this view the Fitchburg granite mass occupies the disturbed ground where at one time the older crystalline schists were thrust up and over the younger sediments.

The presence of schist remnants in the tunnel for several hundred feet west of the Fitchburg granite-Boylston schist contact is not at variance with this interpretation and may support it. The foliation in the granite, and that of the included bodies of schist, is steeply inclined throughout the adjacent section. This structure has been interpreted as the inheritance of a down-drag or fold in the original roof or cover formed by the Brimfield schist. After the Carboniferous sediments had been deposited the rocks were folded and finally faulted, the younger sediments being ultimately crowded over and forming local folds. During the latter stage of deformation the thrust further developed the downfold in the Brimfield schist and the simultaneous invasion of the granitic magma from below further weakened the strata and tended to obscure and destroy the structural detail. Either one of the two structures shown in Figures 12 and 13 could have developed under these conditions. Under one alternative the younger sediments were deformed into closed or isoclinal folds in which no further release from strain was possible and over which the Brimfield schist was thrust. This possibility is indicated by Figure 12. Under the other alternative isoclinal folds developed in both the ancient and younger strata, which were finally overturned, and two thrust faults developed. Either one of the two alternatives, fault or isoclinal folding, accounts for the apparent repetition of strata east of Shaft 1.

The conformable relation of the Boylston schist and phyllitic quartzite of the tunnel is beyond question. The same applies to the phyllite and quartzite mapped as Oakdale quartzite and Worcester phyllite in the area north of the Wachusett Reservoir through which the geologic section of the tunnel has been extended. A principal difficulty in the problem of geologic age and interpretation of structure is the isolated occurrence of the Worcester "Coal Mine" outcrop, from which the age of the Worcester phyllite formation has been determined by fossil evidence. Callaghan[1] has previously recognized the fact that the large section of less carbonaceous phyllite of the geologic section is north of the highly carbonaceous and graphitic "Coal Mine" outcrop. On the basis of having a similar lithology, with the one exception of carbonaceous material, he prefers to correlate the fossiliferous phyllite of the Worcester "Coal Mine" with the phyllite of the geologic section.

A new approach to the solution of these age problems has recently been made in the determination of the geologic age by means of chemical data obtained in analyzing certain radio-active minerals found in some of the igneous rocks intruded into the schists both in Massachusetts and Connecticut. For example, Lane[2] has recently reported the results from a micro-chemical analysis of the mineral uraninite found in the Fitchburg quarries in Fitchburg, Massachusetts. From this data he estimates the granite to be much older than late Carboniferous and probably of late Ordovician age. By using a similar method Foye[3] has found the pegmatite intruding the Bolton schist formation of Connecticut to be of Devonian age. As mapped, this Bolton schist formation is equivalent to the Amherst and the Irving schist formations of Massachusetts, the Amherst being equivalent to the Brimfield or the Brimfield-Ware formations of the tunnel.

It should be noted in the interpretations presented so far that the Fitchburg granite invasion is considered to have occurred during the latter part of the Carboniferous period. Such an age relation for this formation cannot as yet be abandoned in favor of an older age based on chemical data. The chemical determinations suggest, however, that the igneous rocks throughout the area are not all of the same age, and that the same may be true of the schist formations.

The sixth interpretation, which follows, is based on a concept radically different from any yet proposed. The viewpoints presented cannot as yet be definitely proven because they are based only on reasonable inference.

The schist rocks appear to be considerably older than the age previously assigned to them and the evidence also indicates a greater age for some of the igneous rocks.

INTERPRETATION VI — BASED ON CONCEPTION OF DIFFERENT AGES

Assumptions — Different Ages, Thrust Faulting and Igneous Invasion

Worcester phyllite	=	Fossiliferous Worcester "Coal Mine" outcrop	Carboniferous Age
Oakdale quartzite	=	Oakdale quartzite	
- - - - - - - -	=	Unconformity	
* * * * * * *	=	Igneous invasion (Fitchburg granite)	Pre-Carboniferous Age. (Late Ordovician Age?)
# # # # # # #	=	Overthrust fault	
Brimfield Schist	=	Phyllite (of section)	Pre-Carboniferous Age (Ordovician Age?)
Paxton Schist	=	Phyllitic quartzite and quartzite (of section)	
Ware Schist	=	Boylston schist	

This interpretation, illustrated in Figure 14, is an attempt to reconcile the apparent conflicting data of an older age for the Fitchburg granite and the schist formations with the structure and distribution of strata, shown in the geologic section, in proximity to rocks of Carboniferous age. The chief feature is the separation of the phyllite of the Worcester "Coal Mine" outcrop from the less carbonaceous phyllite of the tunnel section extended. The stratigraphic section east of Shaft 1 is then seen to consist of a metamorphosed quartzose sediment over and underlaid by metamorphosed argillaceous sediments. This section is similar to that represented by the Brimfield-Paxton-Ware schist series farther west. These rocks were deposited, metamorphosed, deformed, invaded by granite and eroded long before the Carboniferous period, at which time the fossiliferous Worcester phyllite and underlying quartzite were deposited.

The last three interpretations are based partly on a thrust fault relation between the schists west of the Fitchburg granite and the phyllite and quartzite strata between this granite and the composite formation mapped as "Bolton" gneiss and included schist. Emerson[1] has inferred such a relation on the Preliminary Map of Massachusetts and Rhode Island on which he has drawn a line indicating a possible fault extending from near East Woodstock, Connecticut, to South Charlton, Massachusetts. In this area the Paxton schist is mapped in contact with the Oakdale quartzite. Extension of the fault further north is not indicated but the outline of the Ayer granite mass in this vicinity suggests igneous intrusion along a weakened zone resulting from such deformation. Emerson, Keith and LaForge are in agreement as to the late Carboniferous age of the Ayer granite, which view does not conflict with the relations suggested here.

---

[1] Callaghan, E., op. cit., p. 69.
[2] Lane, A. C., Age of Fitchburg Granite, Science, Vol. 78. No. 2028, Nov. 1933.
[3] Foye, Wilbur G., Private Communication to Chas. P. Berkey, June 22, 1933.

Relation of Construction to Geologic Conditions

In all underground excavation work it is expected that different rock formations will behave differently; better progress can sometimes be made in one formation than in another; one formation is apt to be less treacherous or less inclined to cave, or contains less water, or requires less timbering, or in any number of other ways behaves better than a neighboring formation. During construction of the Quabbin Aqueduct related construction and geologic data, of which the following is a summary, were gathered.

Scaling of Hard Rock

In general the quality of rock in the several geological formations was found to be highly suitable for tunneling operations, and although the rocks are of several different types they are generally of a fairly uniform quality and required very little attention after blasting, other than the usual amount of inspection. A few exceptions deserve comment, however. Excessive scaling of the tunnel arch throughout nearly the entire west heading of Shaft 4, in the Paxton schist formation, constituted a serious menace to safety and threatened to delay the progress of excavation. When the heading had been advanced to a point about 3,800 feet from the shaft, slabs of rock began to fall from the tunnel arch. The condition was most serious in the stretch of tunnel extending from 2,400 feet from the shaft to the heading. The fundamental cause of this behavior was what is known as "air slacking," a condition brought about by the action of air and moisture upon the constituents of the formation. Developing with the lapse of time, the difficulty first attracted serious attention when the easterly end of the section had been exposed to the air for about three months.

Certain peculiar mineral and structural characteristics of the rock were principally responsible for the scaling. The Paxton schist throughout this troublesome stretch is finely laminated and arranged in thin beds which have a general low dip toward the east. The rock is broken by two sets of joints, along which there has been slight movement, into large and small angular blocks and slabs. Both sets of joints were faced with a thin coating of carbonate, chiefly calcite, sometimes associated with iron sulphide minerals. Exposure to the air over a period of time caused oxidation of the sulphide minerals and softened the carbonate, thereby loosening the bond between separate blocks.

This troublesome condition was successfully overcome by the application of two and sometimes three coats of Portland cement mortar shot onto the rock surface as "gunite." Each coat was about ¼ inch thick and was applied in such a manner as to seal all cracks and joints from the air.

A section of tunnel at Shaft 2 also caused considerable concern and necessitated more watchful attention than was generally given in the routine of inspection. This section, which was excavated in the Fitchburg granite where the foliation structure is vertical or nearly so, developed excessive scaling in the arch. This scaling, however, was caused by somewhat different conditions from those responsible for scaling in the Paxton schist. Scaling of the rock in this case was due to confined strains, which, when relieved by excavation, developed horizontal fractures, allowing slabs to fall from the roof. This condition is often called "popping rock." The dangerous situation resulting from this behavior was gradually eliminated by constant attention and prying loose of slabs formed by newly developed cracks.

---

[1] Emerson, B. K., op. cit.

Timbering of Soft Rock

The lengths of tunnel requiring timber support and those where guniting was necessary for the correction of "air slacking" are as follows:

	Length of Tunnel Feet	Per Cent of Total Length
Permanent timber support	1,971	1.5
Temporary timber support	529	0.4
Gunite protective coating	12,046	9.3

Many intrusions of pegmatite, or coarse granite, in the Brimfield formation established conditions causing alteration and gradual decay of the adjacent micaceous schist. Narrow openings and partings along the foliation or bedding planes served as water courses so that the formation as a whole was affected, some portions becoming very soft. Throughout the worst of such sections, timber support for the tunnel roof was necessary (Plate 12). In other stretches gunite was sufficient to stabilize the rock.

Excavation was carried through several zones of crushing and close jointing without any abnormal behavior of the rock. At some points, however, such conditions were responsible for considerable overbreakage on the sides and in the arch. Timbering was constructed in some of these sections, especially where removal of loose blocks did not remedy the condition of "popping rock." In a short stretch of tunnel near Shaft 12 the rock presented considerable difficulty due to its tendency to develop pressure and move into the excavated space. This condition was due to crushing of the rock and extreme alteration of the feldspar constituents to clay.

Ground Water Circulation

Crystalline rock is normally too dense to allow much water circulation, but if such formations are heavily jointed or deeply fissured, or if they are badly broken or crushed by faulting, they may become heavy water bearers and give much trouble. It was noted during construction that water leakage was confined mainly to such structures, which in some cases were developed parallel, or nearly so, to the foliation or bedding of the rock. Small openings along the foliation of the Brimfield and Ware schists allowed a slight but continual seepage of water so that these formations always presented a moist appearance. The other formations of the tunnel area had, by comparison, a very dry aspect except in the vicinity of fractures.

The wettest single stretch in the easterly portion of the tunnel occurred between Shafts 7 and 8, in the Ware schist formation, most of the leakage being confined to the section within one mile of Shaft 8. The second largest water bearer was the Brimfield schist, the larger part of the leakage from which entered the tunnel in the vicinity of Shaft 3. Although water coming from the Brimfield and Ware schist formations was not confined to any particular type of channel there appeared to be some relation between the amount of water and the occurrence of granite intrusions. These igneous intrusions considerably altered the minerals of the schistose rock, especially adjacent to the contacts. Either rock decay has helped to develop fissures sufficient in extent to carry considerable quantities of water or the fissures were developed from deformation and encouraged both water circulation and consequent decay.

The major portion of leakage from the Paxton schist formation and the Fitchburg granite formation was confined to fissures, several of which were found to be lined with calcite crystals. At other points leakage occurred largely from joints. These channels, upon being reached by the heading, yielded considerable quantities of water over a short period and at times temporarily placed rather heavy loads on pumping facilities. After a while, however, the water was depleted and for the remaining construction period the leakage either continued at a greatly reduced rate or else stopped entirely.

The wettest section in the westerly portion of the tunnel was the stretch between Shafts 10 and 11 where excavations were carried through the Hardwick granite formation in which leakages were confined to fractures occurring as joints or as openings parallel to the foliation structure.

Hardness of Formations as Shown by Drilling Speeds

The relative hardness of the several rock formations is shown in Table 1 under the heading "Speed of Drilling." This data represents typical conditions encountered and indicates a wide range in drilling behavior. By far the softest formation was that part of the Brimfield schist occurring throughout the tunnel at Shaft 9 and in portions of the tunnel at Shafts 10 and 11. The behavior of the Brimfield formation in this respect was rather striking; throughout most of its extent the high mica content and general soft condition, due chiefly to alteration of minerals and subsequent weathering processes, was conducive to fast drilling. The portion of this formation extending throughout the east heading of Shaft 4 was considerably harder because of the great number of quartzite beds and granitic bodies.

The hardest formations, with the exception of trap rock, were the Hardwick, Fitchburg and Monson granite formations and the Oakdale quartzite. The Hardwick granite in some sections was a trifle harder than the other two granites. In general these rocks were about three times as hard to drill as the Brimfield schist. Between the extremes of hardness represented by these formations there was a rather uniform hardness represented in the several rock types of the Boylston, Paxton and Ware formations. Of these types, the more quartzose varieties of the Paxton schist, which constitute about two-thirds of the formation, were most uniform in hardness. But for the widespread intrusions of granite into the Ware schist, this formation would have been as soft as some portions of the Brimfield formation.

Methods of Tunnel Excavation

A description of the methods used in tunnel excavation[1] is included in order to supplement the data presented in Figure 15 and Table 1. This data concerns only the performance attained after permanent tunnel equipment had been installed by the contractors. The short stretches of tunnel excavated with equipment used in shaft sinking are shown on Figure 15 in solid black along the lower part of each progress chart adjacent to the shafts and are not considered in this discussion. Shaft 3 was eliminated as a construction shaft soon after construction began under the major contract for constructing the easterly half of the east portion of the tunnel and only a short stretch was excavated from Shaft 1. The contractor completed the excavation between Shafts 1 and 4 from Shaft 2.

At Shafts 2 and 4 and 9 to 12, inclusive, the full-face method of excavation was used. At the first two shafts advancement of tunnel headings was carried on continuously by drilling and mucking crews, which worked on a daily schedule of three eight-hour shifts. The work was so arranged that while blasted rock was being removed from one heading the other heading was being drilled. By this plan the contractor hoped to obtain four advances in one day and five the next. Two ten-hour shifts were employed at Shafts 9 to 12, inclusive, where the number of advances in one day was seldom under four, and at times reached five. At Shaft 12, where excavations were carried on in only one heading, three advances were often made but in order to do this the crews were required to work overtime.

The heading and bench method of excavating was used in the headings of Shafts 5 to 8, inclusive, where the work was organized on a basis of two ten-hour shifts in such a manner as to produce two rounds of excavation in each heading per day. Under this plan drilling and mucking operations were carried on together.

After using this scheme in the headings at Shaft 7 for a while the contractor adopted a modified plan in which drilling and blasting of each heading and bench was accomplished during one shift and mucking during the other. The depth of holes was increased to 10 feet, and blasting was done in two operations, the cut

---

[1] Several accounts concerning construction of the Quabbin Aqueduct have been published, a few of which are listed as follows:

"Construction of Wachusett-Coldbrook Tunnels," by Douglas C. Corner, U. S. Bureau of Mines.

"Boston Metropolitan Water Supply Extension," by Karl R. Kennison. Journal of the New England Water Works Association, Vol. 48, No. 2.

"Constructing a 14-Mile Tunnel for Boston's New Water Supply,' Engineering News Record Sept. 11, 1930.

TABLE 1. TABULATION OF DATA RELATING TO ROCK CHARACTER AND EXCAVATION

Rock Formation		Oakdale Quartzite	Boylston Schist	Fitchburg Granite	Brimfield Schist			Paxton Schist		Ware Schist
Method of excavation		Full face							Top Heading and Bench	
Heading in which formation occurred		Shaft 2—East		2 West	4 East*	9 West	11 West	4 West*	5 East	8 East
Average advance per shot (ft.)		7.3	7.7	7.0	6.5 & 7.3	8.8	8.3	6.8 & 7.3	6.2	6.5
Range in monthly averages—advance per shot		7.1—7.4	7.4—7.9	6.1—7.4	6.1—6.9 6.7—7.8	7.2—9.5	6.6—9.4	6.3—7.8 6.7—7.9	5.8—6.7	5.8—7.5
Number of days of zero advance and conditions responsible	Timbering	0	0	0	5	7	0	0	0	0
	Poor roof	0	0	0	2	0	0	25	1	0
	Water	0	0	0	18	0	0	0	0	32
	Holidays	0	0	2	4	5	5	4	2	2
	Repairs to plant and misc.	0	0	3	7	7	4	11	2	2
Number of daily—										
1 round shots		4	2	51	75	35	24	102	36	62
2 round shots		37	76	362	350	392	216	285	393	306
3 round shots		7	21	37	54	4	0	30	0	0
Range in number of holes in heading		30—32	31—35	30—40		38—40	29—36	32—40	TH 24—32	TH 26—34
Typical heading	Number of holes	31		37		38	32	37	TH—28 B—6	TH—29 B—7
	Av. lin. ft. drilled	287		345		386	346	345	TH—224 B—48	TH—244 B—56
Depth of holes (ft.)	Cut	9				9 & 11	10+	9	8	10
	Relief	8 and 9				9—11	10	8—9	8	8
	Trim	8 and 9				9—11	10	8—9	8	8
Speed of drilling (in./min./drill)	Range	5—9	5—12	5—9	7—15	10—20	7—20	7—11		7—14
	Typical	7	10	7	12	16	13	9		11
Average time required		Number of drills—5				Drills—4		Drills—5	Drills—2	
to drill heading (hrs.)		2—3½	1½—3½	2—3½	1½—2½	1½—2½	2—3	2—3	TH 5—7	
Average time required for cycle of drilling and blasting (hrs.		4—5	3—4	4—5	3—4	2½—3½	3—4	3½—4½	9—10	
Av. lin. ft. of holes per cu. yd. of excavation		6.0	5.7	7.0	7.0	6.5	6.5	7.2	6.5	
Av. lbs. of powder per cu. yd. of excavation		5.0	4.5	6.5	6.0	3.8	4.9	6.2	6.0	

TABLE 1. (Continued) TABULATION OF DATA RELATING TO ROCK CHARACTER AND EXCAVATION

Rock Formation		Hardwick Granite		Monson Granite	
Method of excavation		Full Face			
Heading in which formation occurred		10 West*	11 East	11 West	12 East
Average advance per shot (ft.)		7.3 & 7.8	7.8	8.0	7.7
Range in monthly averages—advance per shot (ft.)		6.8—8.2 7.5—8.2	6.0—8.5	7.6—8.8	7.0—8.9
Number of days of zero progress and conditions responsible	Timbering	0	8	0	0
	Poor roof	2	0	0	0
	Water	0	4	0	0
	Holidays	5	4	0	4
	Repairs to plant and misc.	4	3	0	6
Number of daily— 1 round shots		61	38	17	23
2 round shots		497	372	252	300
3 round shots		0	0	0	78
Range in number of holes in heading		36—44	31—36	29—36	30—42
Typical heading	Number of holes	40	32	36	
	Av. lin. ft. drilled	440	288	396	
Depth of holes (ft.)	Cut	9 & 11	9+		9+ & 11+
	Relief	9—11	9		9 & 11
	Trim	9—11	9		9 & 11
Speed of drilling (in./min./drill)	Range	5—12		5—9	
	Typical	6		7	
		Number of drills—4			
Average time required to drill heading (hrs.)		3—4		2½—3½	
Average time required for cycle of drilling and blasting (hrs.)		4—5		3½—4½	
Av. lin. ft. of holes per cu. yd. of excavation		7.0	6.7	6.5	7.3
Av. lbs. of powder per cu. yd. of excavation		5.7	6.0	5.3	5.1

*In these headings an improvement in the progress of tunnel excavation resulted from changes in the organization. Figures relating to the advance per shot indicate the extent of improvements, so far as the individual rounds or advances were concerned. Additional improvement was made in the sequence of operation so that there were fewer one round days, and more two round days.

Note: TH = Top Heading
B = Bench

and bench holes being loaded and shot first. If, upon examination, the rock was found to have been broken to the full depth required the remaining holes in the heading were loaded and fired. If, as sometimes happened, the rock was not broken to the full depth of the cut holes, additional powder was placed in the bottom of these holes and detonated with the rest of the heading.

Drilling. Drilling of the headings, where the full-face method of excavation was used, was accomplished from drill carriages designed and constructed by the contractors. These carriages were provided with all equipment necessary for drilling the full number of holes. The carriages finally adopted at Shafts 9 to 12 were an improved type of those formerly used, in that the drilling bars, mounting two upper and two lower drilling machines, were an integral part of the carriages. Previous to this installation, and at Shafts 2 and 4, drilling was done by five drills mounted on two horizontal bars, one upper and one lower, which were blocked and wedged to the tunnel side walls. The outline of the headings and the location of drill holes are shown in Figures 16 and 17.

Drilling of top headings was accomplished by two drilling machines mounted on short horizontal arms clamped to two vertical drilling columns, which were blocked and wedged to the tunnel roof and the bench. Bench holes were drilled by mounting the machines used in drilling the headings on a horizontal bar which was located in front of the bench face and wedged to the tunnel sidewalls. A typical drilling diagram showing the location of holes in the top heading and bench is shown in Figure 17.

Mucking. At Shafts 2 and 4 and 9 to 11, inclusive, blasted rock was loaded into steel cars of about 3 cubic yards capacity by means of electric power shovels. At Shaft 12 the contractor installed a drag-line excavator of his own design and manufacture. This machine was equipped with a conveyor belt of sufficient length to allow a full train of five cars, each of 3 cubic yards capacity, to be loaded without the necessity of switching or bypassing cars. With the power shovels it was necessary to move empty cars from the front to the rear end of the train, where the loader could reach them. At Shafts 5 to 8, inclusive, where the top heading and bench method of excavation was adopted, mucking was accomplished by means of mechanical shovels of the air driven type. Hand mucking was used for a short while at Shaft 5 and for a longer period at Shaft 6. Animal power was employed for hauling trains of three cars each of about 1⅔ cubic yards capacity from the heading to the shaft. In headings where the full-face method of excavation was used hauling was done by storage battery locomotives.

Throughout the easterly portion of the tunnel loaded muck cars were hoisted out of the tunnel by means of balanced cages or elevators. Upon reaching the shaft platforms at the surface the cars were run off the cages, made up into trains and hauled to the place of dumping on the spoil pile. Various kinds of motive power, including electric and gasoline locomotives and animals, were used for hauling to the spoil areas. At the shafts in the west portion of the tunnel excavated rock material was dumped into skips similar to those used at some mines. Upon reaching the top of the shaft the skip was automatically dumped and the wasted rock material discharged into cars and transported to the spoil pile. At Shaft 12, due to special requirements, the contractor used motor trucks for distributing excavated material over a large area.

The average time required for drilling and shooting a round in the several headings is shown in Table 1. The average time for mucking at Shafts 2, 4, 9 and 10 was from 2½ to 3½ hours, at Shafts 11 and 12, from 3 to 5 hours, and at Shafts 5 to 8, inclusive, where the top heading and bench method was used, from 5½ to 6½ hours.

Rock Breakage. Separation of the rock formations into blocks by the occurrence of joints or "slips" affected construction operations very little, although in several places high and wide overbreakages were caused by closely spaced joints or by the presence of many intersecting smaller fractures, which had been caused by crushing or other deformation movements within the formations.

Tunnel Rocks as Aggregates in Tunnel Concrete Lining

In the general vicinity of the Quabbin Aqueduct are large supplies of natural sand and gravel suitable for use as concrete aggregates. These supplies are found particularly in the morainal and kame type of deposits located within the larger valleys, in which modified glacial drift is deposited as shown in Figure 2.

The specifications for tunnel construction permitted the use of suitable materials from the shaft and tunnel excavations for concrete aggregates. The rock, with the exception of the soft portions of the Brimfield schist formation extending between Shafts 9 and 10, and in two short stretches adjacent to Shafts 3 and 11, was found to be suitable for this purpose.

Rock crushing and concreting plants were erected at Shafts 2, 4, 7, and 9 to 12, inclusive. Most of the tunnel spoil crushed at these plants was composed of schistose rocks which had been rendered harder and more massive by the large proportion of intruded igneous material. Approximately one third of the spoil material was obtained from granite formations which were considered suitable for aggregate material. The mineral content of the various types of schist and granite, with but one exception, was such as to cause little concern about the resistance of the crushed material to further alteration or decay when incorporated in concrete. Portions of the soft micaceous Brimfield schist excavated from the headings at Shaft 9 disintegrated rapidly in the spoil pile to a sandy and flaky rock material. Only the rock from intruded igneous bodies appeared free from this unstable condition. Consequently, much of the aggregate used in concrete at Shaft 9 was obtained from a nearby sand and gravel deposit and from more suitable material at Shaft 10.

Geology of Main Dam and Beaver Brook Dike

The preliminary investigations indicated that a large reservoir could be created in the Swift River Valley. This reservoir would require construction of a dam on the main river about three miles below the village of Enfield, supplemented by a dike across the valley of Beaver Brook about three miles northeast of the dam on the divide between the Swift and Ware rivers.

The Swift River is one of the principal tributaries of the Chicopee River and drains an area of about 213 square miles above its confluence with the Ware River at Palmer. It is made up of three branches, two of which, the East and Middle Branches, unite in the southwesterly part of the town of Greenwich, about two miles above the village of Enfield, while a third, known as the West Branch, joins the main river about a mile and a half below that village. The watershed of the Swift River is characterized by a series of high ridges running generally parallel in a north and south direction. The middle and upper portions of the valley are occupied by an extensive sandy plain, above the level of which a number of rocky hills rise from 300 to 500 feet. The Middle Branch of the river flows in a southerly direction through this plain from its headwaters in New Salem and North Dana. The East Branch, which drains a high and hilly country in the easterly part of the watershed, enters the plain near its southerly end, joining the Middle Branch near the southwesterly corner of the town of Greenwich. The main river turns abruptly to the southwest not far below this point and enters the comparatively narrow valley in which the town of Enfield is situated. The sand plain, however, extends farther south rising gradually to the broad, low divide between the Swift and Ware River watersheds. This topographic condition makes construction of a dike necessary if the water impounded at the main dam is to be retained in the reservoir. Below the point of confluence of the East and Middle Branches the main river continues through the valley, in which the villages of Smiths and Enfield are located, to its junction with the West Branch, where it turns south and flows through the wider valley below.

Conditions at the low point of the divide between the Swift and Ware rivers northeast of the main dam were found to be unfavorable for the economical construction of a dam or dike at that point, but a favorable site was located in the valley of Beaver Brook about a mile south of the divide, where advantage could be taken of the shorter distance between the side ridges.

The sites chosen were investigated by a large number of borings[1] which provided information regarding the depth to and nature of the rock formations, the number and size of boulders and the quality of the overburden.

The flow line of Quabbin Reservoir will be at an elevation 530 feet above Boston City Base. The reservoir will have a capacity of about 415 billion gallons (1,270,000 acre-feet) and will have a water surface area of about 39 square miles. The flow line will be about 118 miles in length, exclusive of the shore line of the islands. The average depth of water will be about 50 feet. The westerly arm of the reservoir will extend for twelve miles north of the main dam in the valley of the West Branch, and the easterly arm for sixteen miles above the dike in the broad valley of the East and Middle Branches. The drainage area above the dam and dike is 186 square miles. In addition to the Swift River run-off the reservoir may store waters diverted at Coldbrook from a drainage area of 97 square miles of the Ware River, and possible diversions at Shaft 2 from a drainage area of 43 square miles of the Quinapoxet River.

Origin of the Swift River Valley

The Swift River system is a development, during pre-historic times, from three independent but more or less parallel drainage courses; the pre-Glacial or Tertiary "Muddy," "Beaver" and "Swift" rivers. These are indicated on Figure 2. The Tertiary "Muddy" River has already been discussed on page 9 of this report.

The Tertiary "Beaver" River drained approximately the same territory as the present Middle and East Branches of the Swift River. South of Mt. Pomeroy, its several branches formed a single stream which flowed south through Beaver Brook Valley, crossed the Ware Valley, and continued southward through Palmer, and entered the well-defined Monson Valley southeast of Palmer.

The Tertiary Swift River flowed through the valleys of the Swift River West Branch and the Swift River southward to the Ware-Chicopee Valley, whence during a part of the time it may have continued by way of the Quaboag Valley into the Monson Valley.

The rock floors of the Muddy, Beaver and Swift River valleys, in the order named, are successively lower in elevation. At the lowest point in Muddy Brook Valley on the tunnel line the rock floor is about 480 feet above sea level; in Beaver Brook Valley at the dike site the floor is at about Elevation 290; at the main dam the lowest point is at about Elevation 267.

The lower floor of Beaver Brook Valley indicates stream erosion over a considerably longer period than in Muddy Brook Valley and leads to the conclusion that the pre-Glacial "Muddy" River was cut off by the "Beaver" River system during the earlier part of the Tertiary period. There is no evidence to indicate that the difference in elevation of the rock floors is due to materially greater glacial erosion in Beaver Brook Valley than in Muddy Brook Valley, and, although glacial erosion had a prominent part in their formation, stream erosion was a more important factor in first eroding and fixing the general trend of these valleys.

The final stage in the development of the Swift River was completed when the "Beaver" River was cut off and captured by the Tertiary Swift River West Branch through dissection of the divide between the two.

The broad valley of the Middle and East Branches north of the dike is an interesting and peculiar topographic feature for which certain geologic conditions were partly responsible. The outline of the valley conforms to the boundaries of the Monson granodiorite formation which is flanked by schist strata outcropping in the side ridges. The narrow portion of the valley in which the dike is located is also the section where the flanking schist rocks are closest. The topographic expression of the valley and the distribution of the rock formations is not merely a coincidence, for it seems the first is dependent upon the latter. Before the Glacial period the rocks were extensively weathered and decayed. This is particularly true of the granodiorite formation where weathering was greatly accelerated by reason of the steep foliation or bedding structure, the coarse grain, the great abundance of feldspathic constituents, and the fact that it is broken up by several sets of joints, a prominent one of which is nearly horizontal or at right angles to the foliation. The schist rocks are of finer grain, contain much less feldspar, and fewer joints, and consequently were more resistant to weathering and decay. As the glacier advanced southward in the valley the thick mantle of decayed rock was removed by abrasion, permitting the ice to penetrate into the many cracks and other weaknesses of the rock and wedging blocks of rock further apart. These blocks were eventually dislodged by, and carried along in, the glacial ice. The two principal weaknesses of the granodiorite, the steep foliation and the horizontal set of joints, aided this type of erosion or glacial plucking. The schist rocks were better able to resist this kind of erosion, chiefly because of fewer joints in the directions more apt to facilitate plucking action.

---

[1] Hammond, N. LeRoy, Diamond Drill Borings for the Swift River Dams, Journal of the Boston Society of Civil Engineers, January, 1929.

Detailed Investigations at Main Dam and Beaver Brook Dike

Borings at the sites of the main dam and the dike penetrated bedrock to depths of at least 15 feet and samples of the overburden were taken at 5-foot intervals and in some cases more often. These explorations revealed wide, smooth valleys and showed that the underlying rock was of good quality and substantial. Its crystalline character was found to be such that no special construction difficulties were anticipated. The overburden was found to be thick and porous, substantial enough to support the contemplated structures but not sufficiently impervious to hold back the reservoir water. The porosity of the overburden, together with its great thickness, necessitated a type of construction that would not permit leakage under the structures.

Four concrete exploratory caissons, one at the dike and three at the dam, were constructed in order to permit more thorough investigation of the qualities of the overburden, the feasibility and cost of open and pneumatic caissons for cut-off walls and the possibility of lowering the ground water by pumping. As the sinking of the caissons progressed to bedrock the drift material was sampled continuously for purposes of studying its characteristics. From information obtained by sinking these caissons and the subsequent pumping from them, it was shown that the ground water, which, at the dam site, was approximately at river level, about 120 feet above the low point of ledge, and at the dike, at brook level, about 130 feet above the low point of ledge, could be satisfactorily lowered so that the larger portions of the concrete core wall at each site could be built in the dry or with very low air pressure and that caisson construction for use as a cut-off wall was feasible for both sites, providing an economical and satisfactory cut-off. Such core walls, constructed by sinking and afterwards joining a series of similar caissons, have been constructed at Beaver Brook dike and at the main dam.

Detailed investigations of the natural materials adjacent to the sites were made for purposes of studying their use and behavior in the dam and dike. Samples were carefully gathered and tested in the Soil Testing Laboratory. The depth of deposits was determined by borings and detailed observations were made in test pits and large shovel cuts. In this way deposits were exposed on a large scale and a better understanding of the range in variety of the materials obtained.

Glacial Deposits of Beaver Brook and Swift River Valleys

The deposits within the Beaver Brook and Swift River valleys consist chiefly of modified glacial drift. These are assorted and stratified sand and gravel with bouldery accumulations. Within these two valleys a relation exists between the topographic expression of the surface forms and the distribution and character of the modified and unmodified deposits. In general, the unmodified drift of the ground moraine which occurs in the higher areas was deposited directly by the ice with very little if any assorting action by water and as a result the ground surface throughout these areas is quite regular and the underlying rock topography conforms roughly to the surface topography. In contrast, the irregular surface topography formed by gravel and sand knolls and ridges, due to the irregular deposition of materials by glacial streams flowing in channels under the ice or along the front and sides of the ice, is typical of the areas in which the modified drift occurs. Parts of the modified drift, especially in the Swift River Valley, consist of terrace-like deposits which often occur on both sides of the valley at approximately the same elevations. These terraces represent deposition between an ice lobe of the receding glacier and the valley side hill, or in some cases, the remnants of a blanket deposit which was originally spread over the surface of the valley glacier. As the ice melted, portions of the deposits slumped and were carried away, leaving those on the sides more or less undisturbed. These deposits now appear as terraces having flat or gently sloping surfaces.

The great variation in quality and texture presented by the modified drift, as well as variations in the structural relations and extent of individual layers, lenses, and beds, is a direct result of the way in which they were deposited. Layers of sand or gravel pinch out and change in quality along their lateral extent. They are overlapped by other layers which differ from them sufficiently to form a succession of beds, the whole assemblage forming a variably assorted deposit.

Materials for Construction

Areas upstream and downstream from the dike site within a reasonable hauling distance and which surface conditions indicated might be expected to yield suitable materials for earth dam construction, were investigated to determine quantities of overburden available above the ledge, and samples from test pits and bore holes were taken for mechanical analysis and other tests for suitability. The materials in each of the probably usable areas were then further investigated by excavating a shovel cut to a face 25 or 30 feet high. The topsoils available within a reasonable distance were also sampled and tested.

In the upland areas northeast and northwest of the dike topsoils were found to be available in sufficient quantity to provide impervious material for refilling the open trench excavation adjacent to the concrete core wall and for preparing the foundations for the hydraulic core of the embankment above.

Explorations of possible borrow areas for materials for the main dam were made both upstream and downstream from the site in similar manner to that employed at the dike. Sufficient quantities of suitable materials were found to be available for hydraulic construction and there is a sufficiency of topsoils upstream from the site to furnish impervious filling as required.

The embankment for the main dam will contain about 4,000,000 cubic yards and that for the dike will require about 2,500,000 cubic yards. The top of the embankment at both dam and dike will be at Elevation 550, 20 feet above the normal full level of the reservoir.

Cross Section of Valley at Main Dam and Beaver Brook Dike

The data used in preparing the two cross sections, Figures 18 and 19, concerning the glacial overburden at the dam and dike, was obtained by actual observation and measurements during construction of the caisson cut-off walls. The sections show the actual number and distribution of large boulders having volumes in excess of one-half cubic yard.

The terms used in the legend to describe the gravels, which were found to be extremely variable in texture, refer to the average composition of the sand portions, which often consisted of layers and small beds of fine sand and rock flour. The materials classed as coarse and medium sand, fine sand and clay, rock flour and silt, especially the latter two classes, show considerable uniformity in texture throughout their extent. It will be noted that a large part of the overburden in each valley is the material designated as gravel containing coarse and medium sand.

The sand and gravel beds certainly were not all deposited under similar conditions, although they were all laid down during the final stages of glacial recession when the valleys were being freed of ice. Some of these deposits were formed while the glacier still remained in the valleys, others, when there was little, if any, glacial ice left.

The beds of fine sand, clay, rock flour and silt were deposited in shallow ponds and lakes formed behind temporary dams composed of glacial drift and ice. The coarser sand and gravel materials were deposited upstream, but the finer sediments were carried downstream in suspension, finally settling out to form fine sand and clay beds which are often laminated. These deposits do not necessarily represent a single stage of release from glacial ice followed by deposition, for they could have been, and frequently were, deposited, eroded, and redeposited before being laid down in their present formations.

Several beds of rock flour, which occur at intervals throughout the vertical extent of a thick deposit of fine sand, are shown in the cross section of the dike, Figure 18. These are essentially the same as lake deposits and indicate repetition of conditions which favored the formation of clay or rock flour bands.

The abrupt change on the east side of the valley from deposits of uniform texture to those showing great textural variability is due chiefly to the finer grained sediments having been deposited against a wall of ice and drift which occupied the middle portion of the valley. The beds of fine-grained material on the west side and in the upper middle portion of the valley apparently were deposited in depressions formed by ice blocks. Similar clay and rock flour deposits of limited size occur as small bodies or lenses in larger deposits of coarser sand at scattered points throughout the valley.

The cross section of the dam shows only a few minor deposits of extremely fine grained material. Rock flour, clay and silt were encountered here at many points but these occurred in small lenses and thin beds and in only a few instances in sufficient magnitude to allow estimating their continuity. A large part of the overburden, however, is capped by a rather thick deposit of uniform fine sand varying somewhat in texture, and occurring in thin beds or streaks of rock flour or clay and somewhat larger beds of coarser sand. This deposit was formed in a temporary lake or pond or was laid down under conditions where the carrying capacity of the glacial streams was greatly reduced. Similar sand strata occur for several miles north in the valley and form the extensive flat areas so much in evidence.

The origin and the method of deposition of the boulders in the coarser gravel deposits, all of which are too large to have been transported by glacial rivers, are particularly interesting. As the glacier advanced over the country large blocks of rock were picked up and became firmly lodged in the lower part of the glacier and were carried along by it. When changing climatic conditions halted the advance of the glacier and recession of the ice began, large quantities of sand, stones and boulders were dislodged. This melting process took place not only on the exposed upper surface of the glacier but also along the under side. Parts of the sub-glacial accumulations thus formed were carried along by sub-glacial streams and eventually deposited, but the larger boulders, upon being dislodged, remained in much the same position that they assumed when dropped by the ice, accounting for the distribution and concentration of boulders in the lower portions of the valley overburden.

The concentration and size of boulders at the dike site was greater than at the dam site, thus substantiating to some extent the explanation of the broad Swift River Valley in Greenwich and New Salem. The increased width of the valley in this section has been ascribed to lateral erosion by glacial scour after the main trend of the valley had been fixed by pre-Glacial stream erosion. As there is no difference in rock character between the boulders and the Monson granodiorite the evidence points toward the conclusion that practically all of the boulders at the dike were plucked from the Monson granodiorite formation.

Rock Formations of the Valley Floor

The rock formations at the dam and dike are different both in character and origin. The simplest rock type occurs at the dike and may be briefly described as a foliated gray granite but technically it is a variety of granite and is known locally as the Monson granodiorite, which has been described in this report as an important tunnel formation between Shafts 11 and 12.

The rock at the dam showed considerable variety in character and behavior. Considered as a whole it might be classed as an injection schist or gneiss and in many ways is similar to the schist formations along the tunnel. There are three principal rock types represented as follows:

1. Micaceous schist, which is similar to the Brimfield and Ware schist ormations.

2. Sandy or quartzose schist, which is similar to the Paxton schist formation.
3. Igneous rock, granite and pegmatite.

The schistose varieties are largely interbedded and have been strongly deformed into small sharp folds. The great variation in these rocks is further emphasized by the abundance of igneous intrusions in the form of small dikes, veins, bands and lenses. These intrusions more often occur as granite or pegmatite bodies which are oriented parallel to the foliation structure of the schist. Veins and dikes also occur which transect the schist strata. All stages of granitization of the schists may be seen, which is a direct result of intense soaking by granitic constituents. On the Geologic Map of Massachusetts and Rhode Island the two varieties of schist are mapped as separate formations, the Erving schist and the Amherst schist. The evidence which would warrant such a classification was not found in the section exposed at the dam. The interbedded relations of micaceous and sandy schist was observed frequently in the Brimfield and Ware formations of the tunnel, and in the Paxton formation, especially near the contacts of the middle member. It is certain that these rocks at the dam are related to one of these formations, but to which one it is difficult to say.

As the caissons for the dam and dike core walls reached the underlying rock floor the rock surface was cleaned and such rock as was not thoroughly a part of the ledge formation was removed. Much of this consisted of broken and detached blocks caused by jointing and by cracks along the foliation structure. A comparison of the two cross sections shows the relative amount of this kind of excavation and also indicates the condition and relative soundness of the original rock floor at the time it was exposed. The Monson granodiorite at the dike was found to be of a very substantial quality, only a small amount of rock excavation being necessary. The original surface in general was found to be hard and few instances of extensive rock decay were noted. The rock floor exposed by the caissons is an eroded surface protected originally by a rock cover, which was removed later by glacial abrasion and plucking. Weathering has attacked the rock very little since glacial times.

The quality of the rock at the dam was inferior to that at the dike, the micaceous schist strata being badly weathered and decayed in places, and considerably more excavation was required in order to reach sound rock. This condition, by reason of the steep foliation and interbedded character of the rocks, extended to considerable depths. The granitic portions and quartzose schists, in contrast, were sound, but considerable volumes of this better quality of rock were removed in order to remove the soft micaceous rocks. The beds of the different schist strata cut across the axis of the dam nearly at right angles, which made it all the more important to reach sound bedrock.

At least some of the decayed rock is judged to antedate the glacier. The two rock spurs, which cause the valley to become narrower and which form the dam abutments, acted as buffers in minimizing the amount of glacial abrasion. Also the effect of plucking was less here than at the dike because of fewer horizontal joints, which, however, were present in small numbers and necessitated the removal of the resulting disjointed blocks.

Geological Studies Related to Highways

Highway Locations

The Quabbin Reservoir will necessitate the abandonment of many miles of roads in substitution for which about 26 miles of new highway have already been constructed, about 5 miles being between the present Ware-Enfield road and Belchertown, and the remaining 21 miles a continuous stretch along the west side of the reservoir from Belchertown to within 4 miles of Orange, known as the Daniel Shays Highway.

Foundation and Pavement Materials

A geological survey of the country through which the new highways extend was made, the object of which was to locate sand and gravel deposits suitable for road foundations and to determine the suitability of some of the rock formations for use as road material.

Extensive deposits of modified drift, sand and gravel were known to occur in the valley of the Swift River West Branch. Except for a short stretch where the highway crosses this valley these deposits are located from 2½ to 5 miles hauling distance, over steep grades, from the new road. Borrowing foundation material from this area would be expensive and a special effort was made in surveying the higher ground to locate sand and gravel deposits, a few of which were found which had collectively sufficient volumes of material suitable for the foundations. The deposits appear to be confined to rock depressions and small valleys which are tributaries of the Swift Valley. During the retreat of the glacier the outlets of these depressions became clogged, in much the same manner as the larger valleys, causing sand and gravel materials to be deposited.

The physical properties of toughness and hardness required in crushed stone for road metal are such that only rocks of igneous origin are suitable. A particular type of igneous rock known as diabase or trap rock fulfills the requirements most satisfactorily and in practice has become the standard material for macadam roads. Occasionally, however, other types of igneous rocks are found which are also suitable for the wearing or top course of pavements.

The rocks along the highway and throughout the adjacent country are of a crystalline character and mostly of igneous origin. The several varieties known to be available included igneous granite and diorite and an igneous quartzose rock. The quantity of crushed stone required was about 117,000 tons and it was believed that if this quantity of stone could be quarried from some local rock formation the savings might be quite appreciable. Otherwise the road metal would have to be obtained from commercial trap rock quarries.

The country adjacent to the highway was carefully surveyed and a few large ledges of igneous rock were found which showed promise as potential quarry sites. The several sites examined eventually were reduced to four, two of which were located in a dioritic formation, one in a quartzose rock formation, and the other on a newly discovered diabase or trap rock dike. The trap dike is located about three miles north of Pelham, a short distance over the town line in Shutesbury. It cuts across the highway at this point, varies from 75 to 100 feet or more in width and extends cross-country for several miles in a northeasterly direction. It is shown on the geologic map, Figure 10.

Tests of samples from the four prospective quarry sites proved two to be suitable for the surface course of the pavement; one very nearly passed the test, and the other failed. The rocks submitted for physical tests represent a rather wide range in character and their relative value as road material is shown as follows:

Rock Character	Location	French Coefficient of Wear	Toughness	Remarks
Diabase (trap rock)	Shutesbury	21	33	Suitable for both top and bottom courses.
Massive diorite	Packard Mt. New Salem	15	10	Suitable for bottom course. Average rock probably more suitable than indicated.
Igneous quartzose rock (Slightly foliated)	Pelham	17	15	Tested rather favorably but its average quality is more adapted to secondary road construction.
Foliated, banded diorite	Orange-New Salem	12	5	Poor quality and unsatisfactory.

The information relative to the location and character of the materials available for road materials was furnished to prospective contractors and the contracts provided that the trap rock dike which was located on land owned by the Commission might be used by contractors for road construction. The successful bidders purchased stone from commercial trap rock quarries at prices which were undoubtedly much lower than would have been the case had the presence of this trap rock deposit not been discovered, resulting in substantially lower prices to the Commonwealth.

SUMMARY

Construction of the Quabbin Aqueduct and Reservoir has contributed toward a better understanding of the geology of central Massachusetts. Some of these contributions consist of the presentation of new geologic data, whereas others merely emphasize the difficulties involved in reaching a full understanding of the geological history of this part of the state. Certain portions of the material presented concern the more practical or applied aspects of the geology as related to the several structures. The points of particular interest regarding these two phases, which have been elaborated in the text, may be summarized as follows:

1. Geologic formations have been restudied and in a few cases redefined. The Paxton schist formation was found to be composed of two similar members separated by a third dissimilar member and not of a single unit as previously described and mapped. The Brimfield type of schist was found to occur both above and below the Paxton series, which made it necessary to designate one of these occurrences by the new formational name of Ware schist.

2. A geologic section showing the distribution of formations and the geologic structure over a belt 30 miles wide is included. All but five miles of this section was studied in the tunnel where fresh exposures were available and where the geology could be mapped in greatest detail.

3. The question of relative geologic ages of the schist formations on the one hand and the recognized Carboniferous rocks on the other is still unanswered despite the excellent opportunity to view the schist formations in the tunnel. This uncertainty is due to the large mass of Fitchburg granite separating the formations into two belts and destroying much of the required evidence. Several alternative structure sections drawn through this critical area have been submitted. These do not contribute a positive solution to the age problem but they do serve the purpose of emphasizing the conflicting evidence both structural and chemical. As stated previously, the schist formations are believed to be older than the Carboniferous rocks and may be of Ordovician age or even older.

4. The Fitchburg granite was found to contain large masses of schist in all stages of granitization. These masses, remnants of an older rock series, show a strong foliation structure which is distinguishable even in the portions represented by intrusive granite. A large part of the granite has been formed by injection and replacement of the Brimfield schist. The foliation structure of the granite has been inherited from that of the older schist rocks. Such an explanation of origin is also applicable to portions of the Monson and Hardwick granite formations.

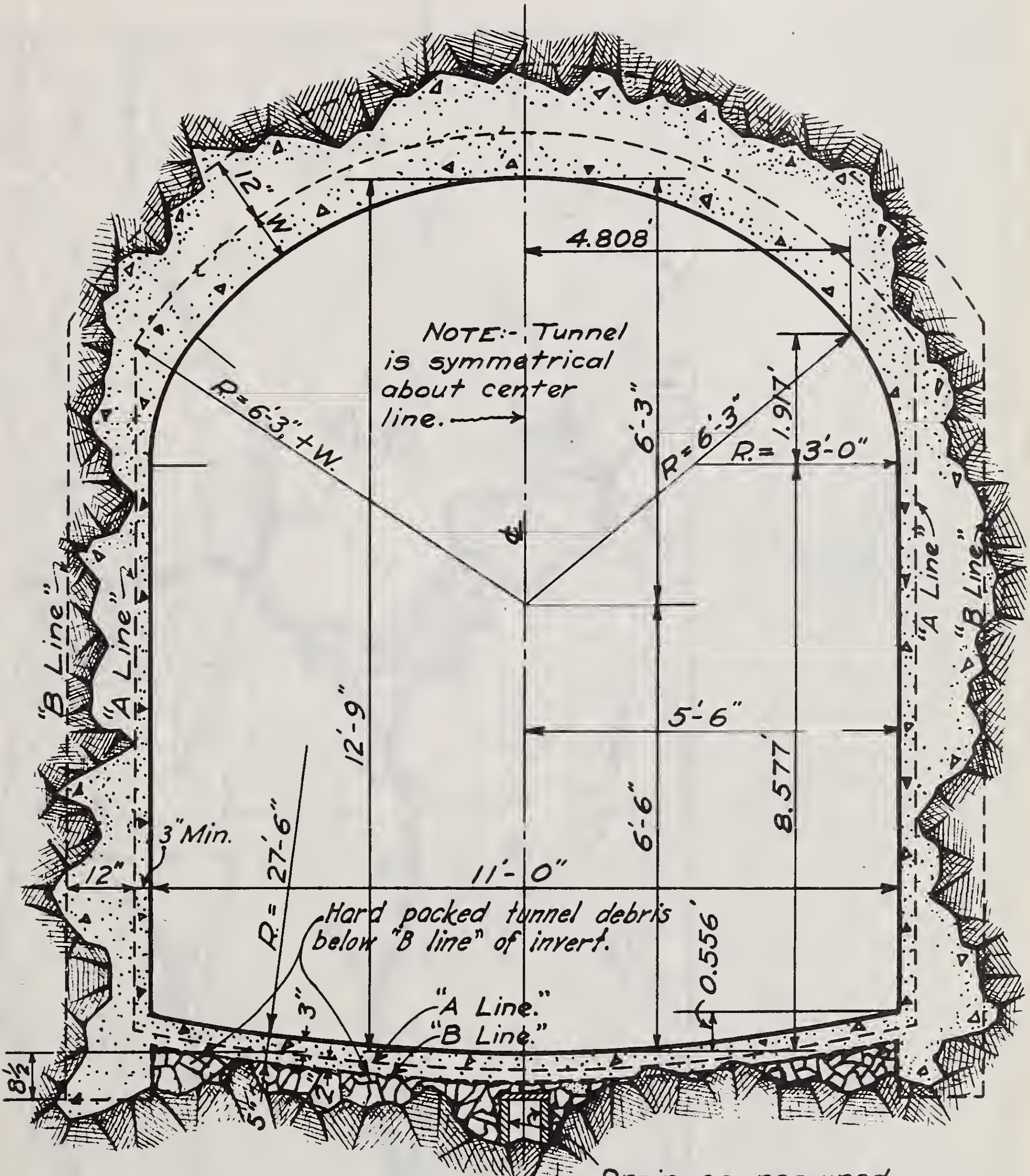
5. Sixty drawings showing the detailed geology of much of the tunnel are appended to this report. These, together with the hundreds of rock samples housed in the Ware River intake building at Shaft 8 near Coldbrook, constitute a unique record of actual geological conditions.

6. The most important pre-Glacial or Tertiary rivers have been traced and rock profiles based on borings have been drawn. These profiles indicate the depth to which some of the Tertiary valleys were eroded before they were filled with glacial materials.

7. Construction of the cut-off structures of the main dam and Beaver Brook dike has made it possible to present generalized cross sections of the valleys in which these are located. The detail presented in these sections, especially that related to boulders, indicates the character and quality of the glacial overburden more accurately than would have been possible by interpretation of borings alone.

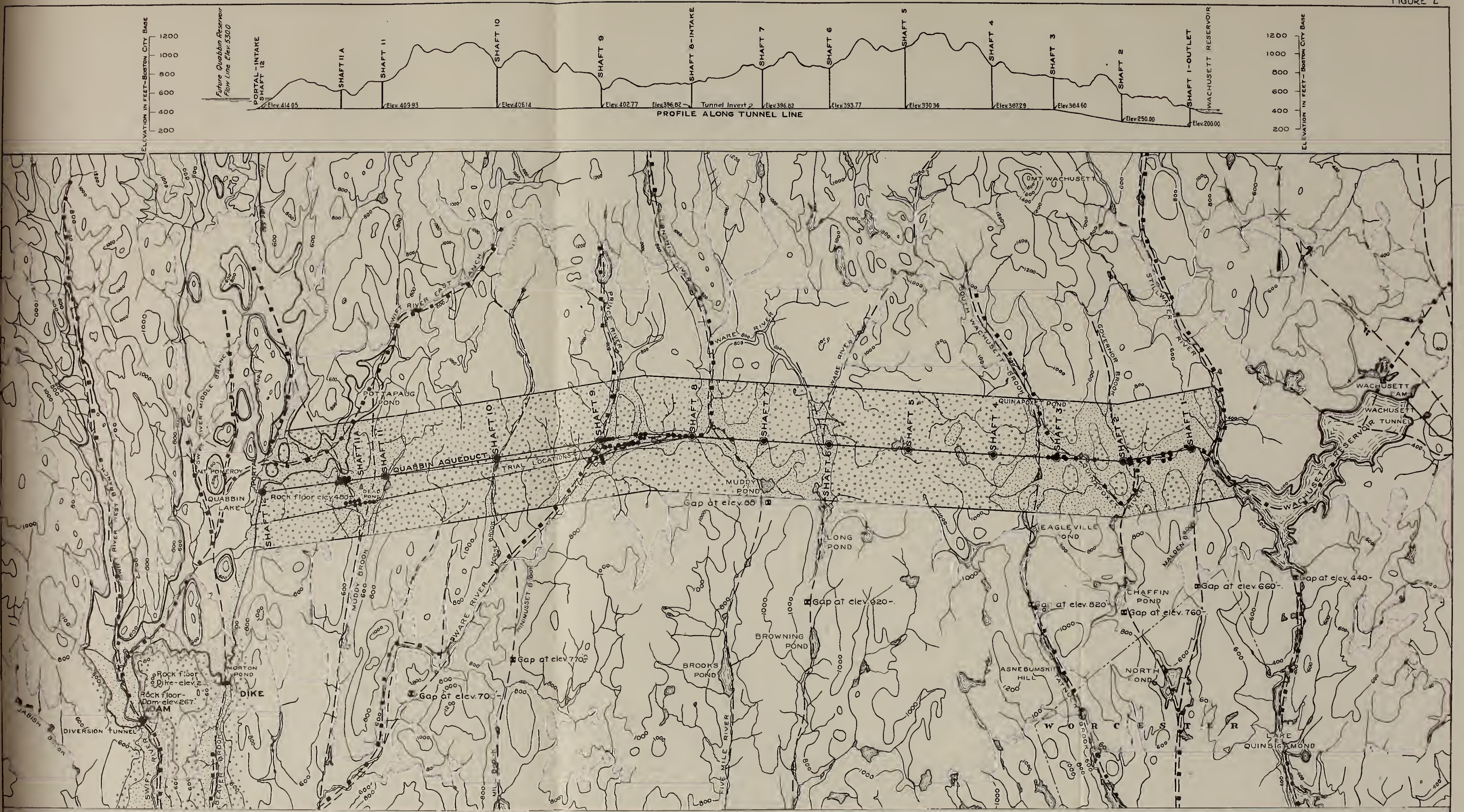
8. The tables and charts concerning construction are submitted as a record of the performance attained in construction of the tunnel which is further correlated with the several rock formations.

FIGURE 1



TYPICAL TUNNEL SECTION

FIGURE 2



LEGEND

⁘ Unmodified drift–ground moraine–mixed composition, chiefly rock flour, sand, gravel, and boulders. Deposited to shallow depths–generally 0–35± ft.

░ Modified and semi-modified drift. Includes morainal and glacial lake deposits and outwash sands and gravels. Deposited to variable depths–generally 25–200 ft

Solid circles indicate location of borings.

— — — Earlier pre-glacial or tertiary streams.

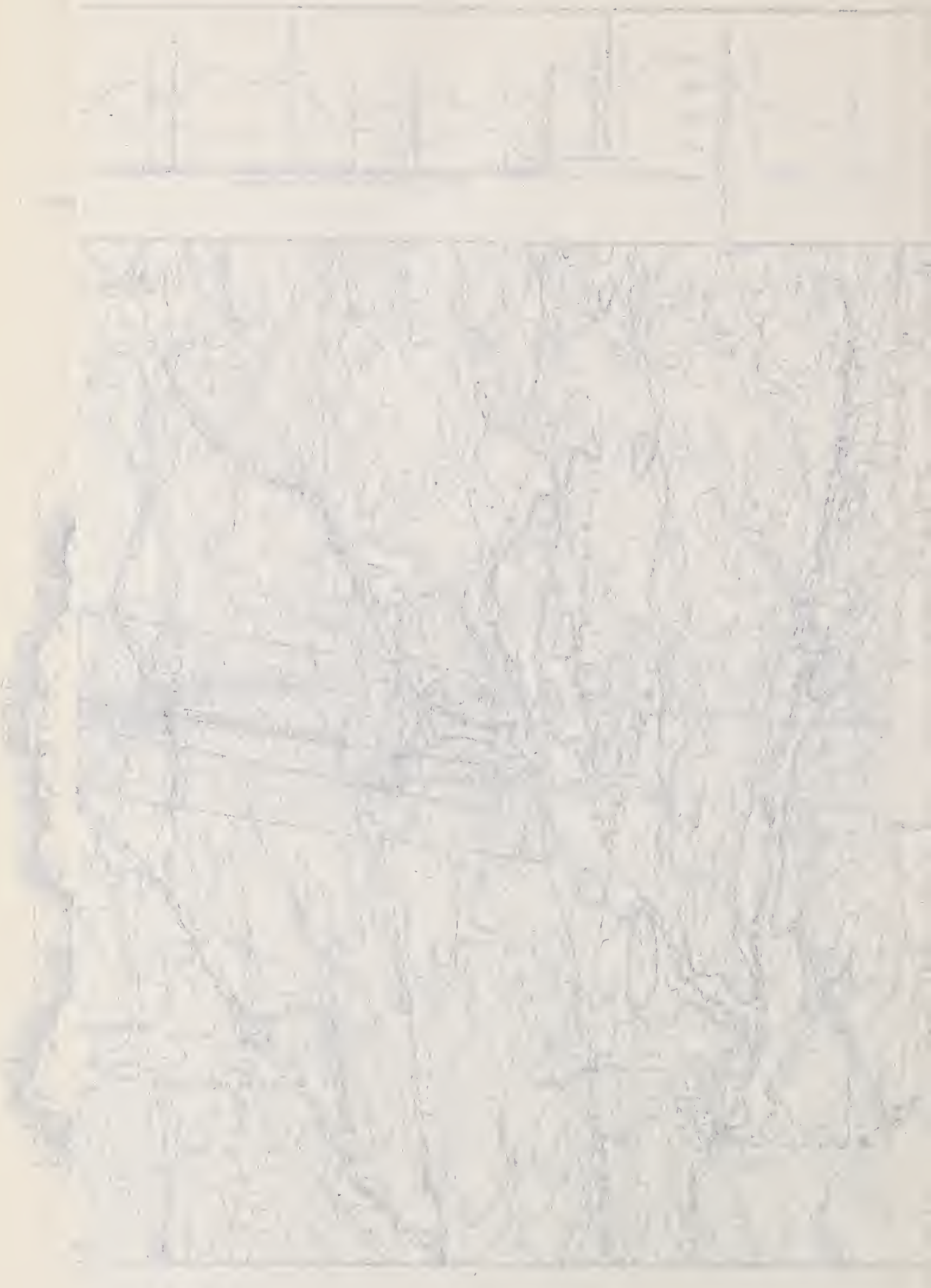
—■—■— Later pre-glacial or tertiary streams.

⁓ Present streams

● Borings.

COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN DISTR. WATER SUPPLY COMMISSION
GENERAL MAP OF QUABBIN AQUEDUCT AND RESERVOIR AREAS
DISTRIBUTION OF GLACIAL DRIFT
PRINCIPAL TERTIARY DRAINAGE COURSES

1 ½ 0 1 2 MI.



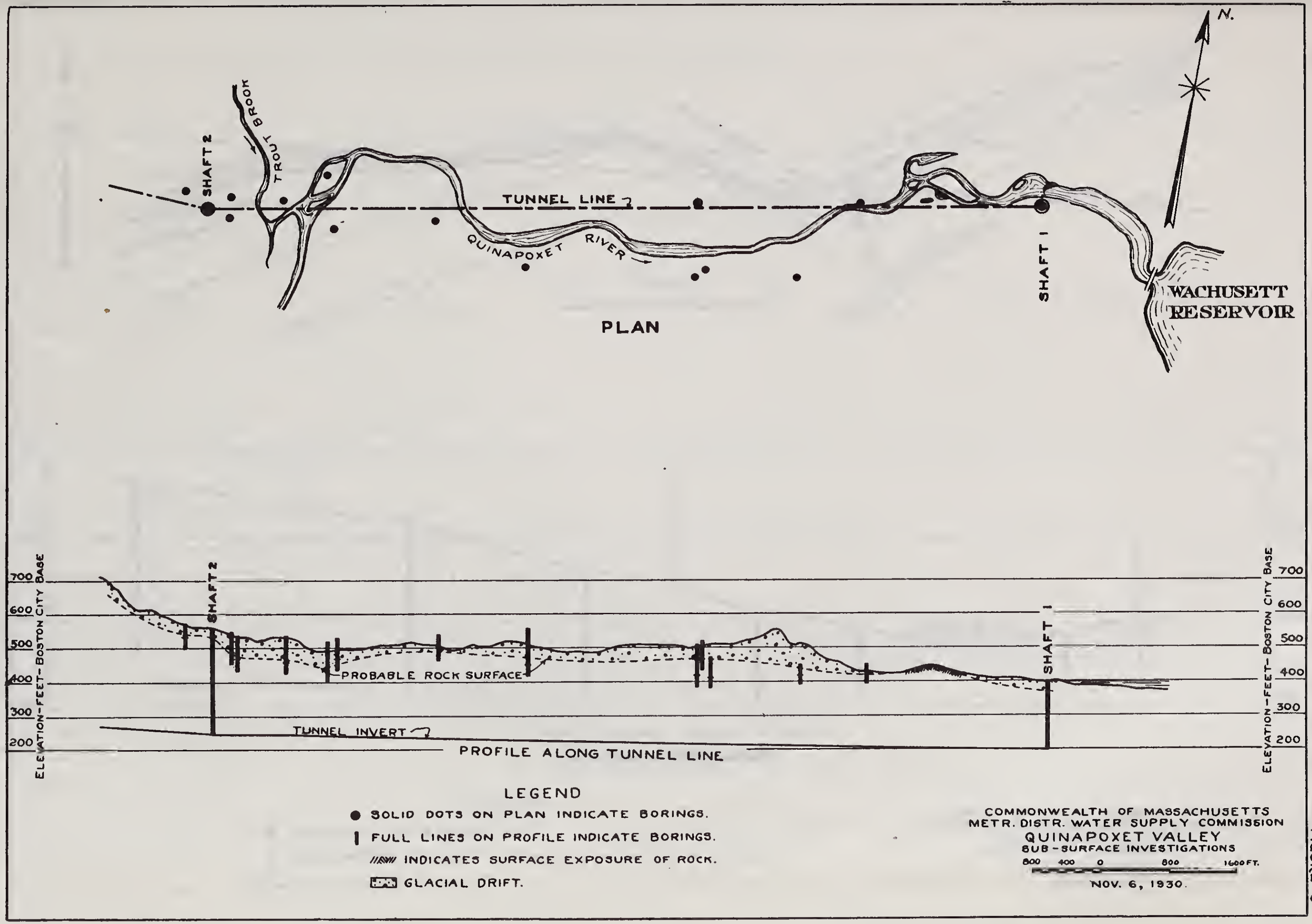

N.
SHAFT 2
TROUT BROOK
TUNNEL LINE
QUINAPOXET RIVER
SHAFT 1
WACHUSETT RESERVOIR
PLAN
ELEVATION-FEET-BOSTON CITY BASE
700
600
500
400
300
200
SHAFT 2
SHAFT 1
PROBABLE ROCK SURFACE
TUNNEL INVERT
PROFILE ALONG TUNNEL LINE
LEGEND
● SOLID DOTS ON PLAN INDICATE BORINGS.
| FULL LINES ON PROFILE INDICATE BORINGS.
INDICATES SURFACE EXPOSURE OF ROCK.
GLACIAL DRIFT.
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUINAPOXET VALLEY
SUB-SURFACE INVESTIGATIONS
800 400 0 800 1600 FT.
NOV. 6, 1930.

FIGURE 3

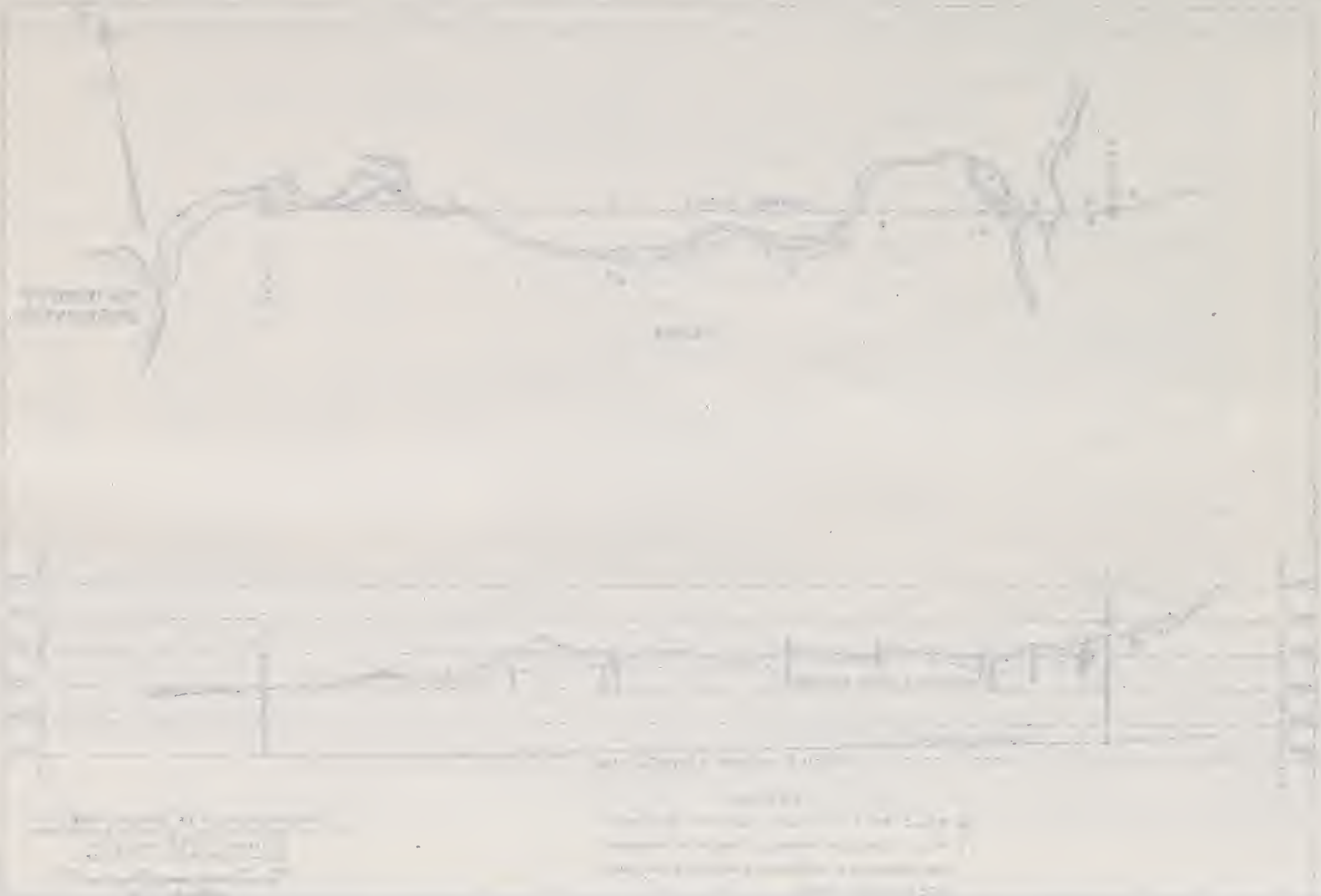
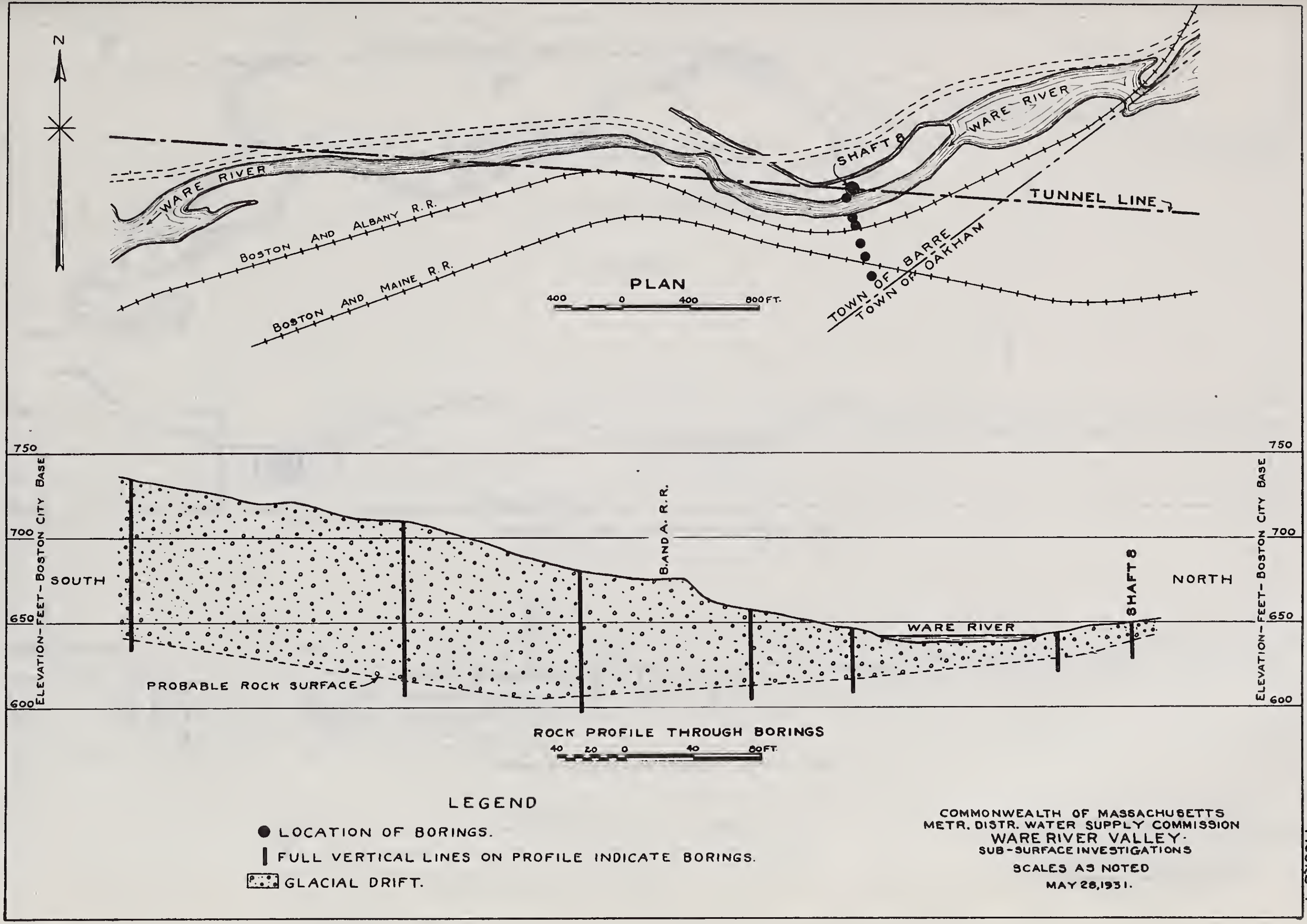


FIGURE 4



LEGEND

● LOCATION OF BORINGS.
| FULL VERTICAL LINES ON PROFILE INDICATE BORINGS.
▨ GLACIAL DRIFT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
WARE RIVER VALLEY
SUB-SURFACE INVESTIGATIONS
SCALES AS NOTED
MAY 28, 1931.

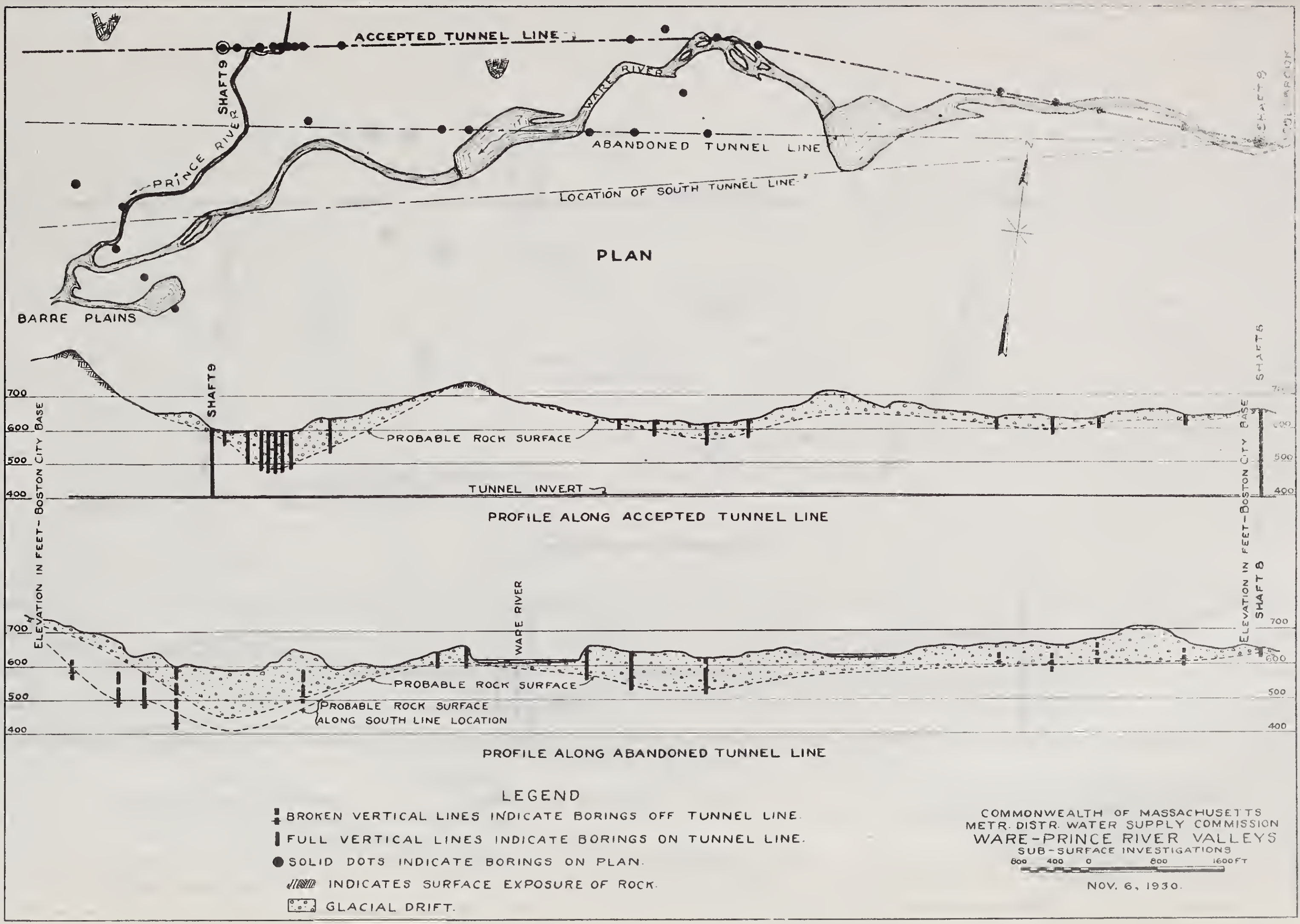

ACCEPTED TUNNEL LINE
SHAFT 9
PRINCE RIVER
WARE RIVER
ABANDONED TUNNEL LINE
LOCATION OF SOUTH TUNNEL LINE
SHAFT 8
PLAN
BARRE PLAINS
700
600
500
400
ELEVATION IN FEET-BOSTON CITY BASE
SHAFT 9
PROBABLE ROCK SURFACE
TUNNEL INVERT
SHAFT 8
PROFILE ALONG ACCEPTED TUNNEL LINE
WARE RIVER
PROBABLE ROCK SURFACE
PROBABLE ROCK SURFACE ALONG SOUTH LINE LOCATION
PROFILE ALONG ABANDONED TUNNEL LINE
LEGEND
BROKEN VERTICAL LINES INDICATE BORINGS OFF TUNNEL LINE.
FULL VERTICAL LINES INDICATE BORINGS ON TUNNEL LINE.
SOLID DOTS INDICATE BORINGS ON PLAN.
INDICATES SURFACE EXPOSURE OF ROCK.
GLACIAL DRIFT.
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
WARE-PRINCE RIVER VALLEYS
SUB-SURFACE INVESTIGATIONS
800 400 0 800 1600 FT
NOV. 6, 1930.

FIGURE 5

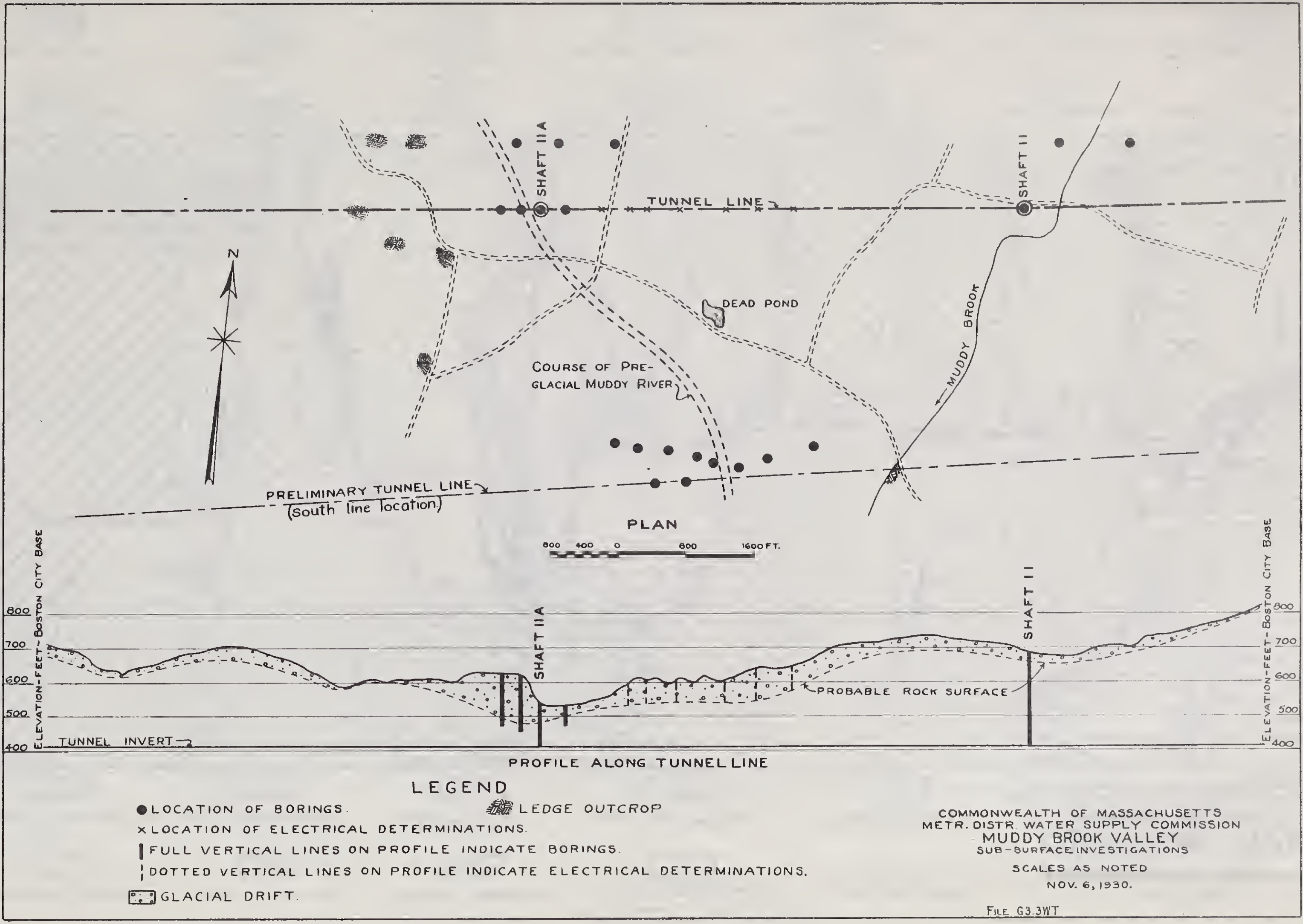
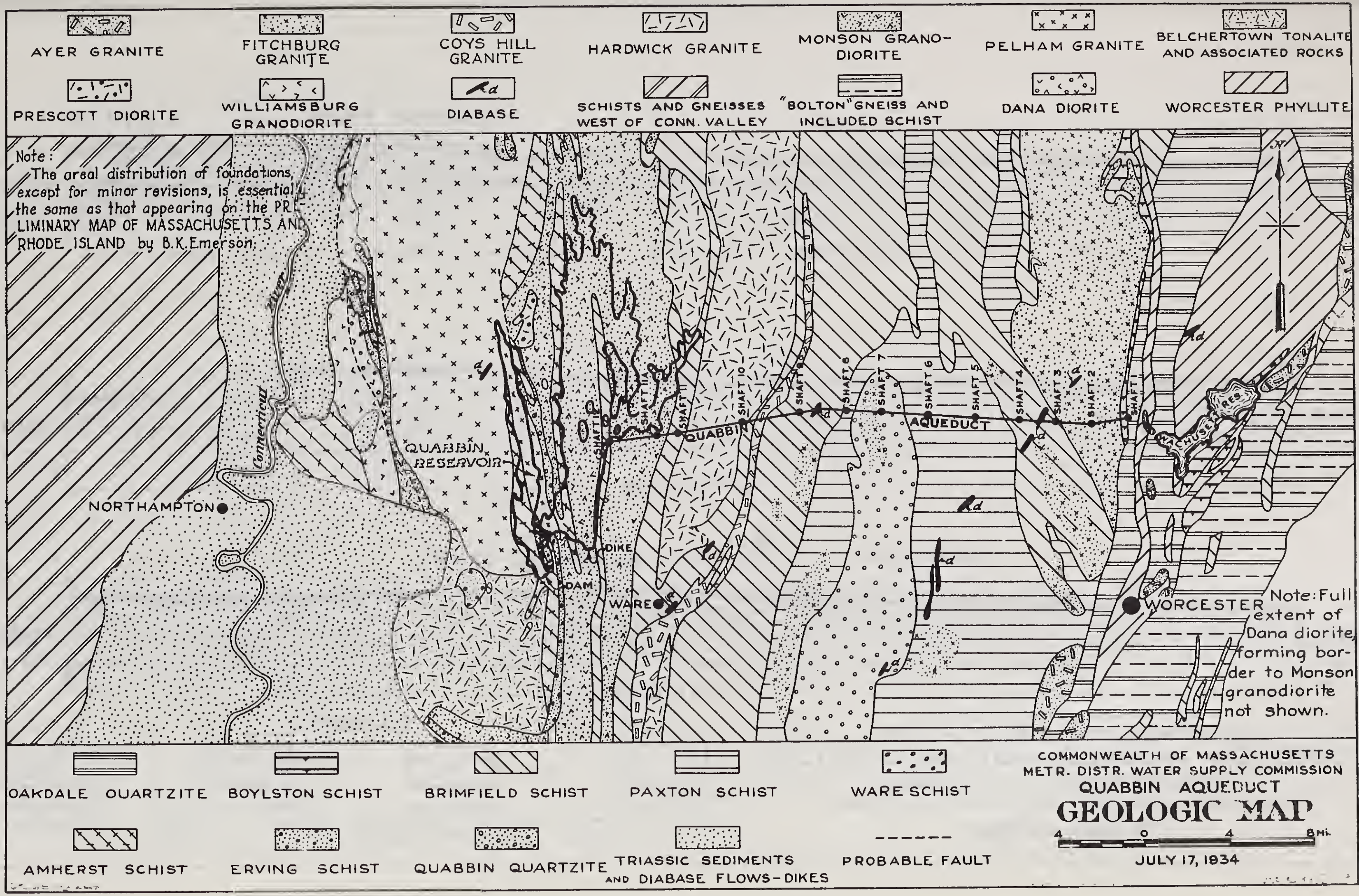

SHAFT IIA
TUNNEL LINE
SHAFT II
N
DEAD POND
MUDDY BROOK
COURSE OF PRE-GLACIAL MUDDY RIVER
PRELIMINARY TUNNEL LINE (South line location)
PLAN
800 400 0 800 1600 FT.
ELEVATION-FEET-BOSTON CITY BASE
800
700
600
500
400
TUNNEL INVERT
PROBABLE ROCK SURFACE
PROFILE ALONG TUNNEL LINE
LEGEND
● LOCATION OF BORINGS.
LEDGE OUTCROP
× LOCATION OF ELECTRICAL DETERMINATIONS.
FULL VERTICAL LINES ON PROFILE INDICATE BORINGS.
DOTTED VERTICAL LINES ON PROFILE INDICATE ELECTRICAL DETERMINATIONS.
GLACIAL DRIFT.
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
MUDDY BROOK VALLEY
SUB-SURFACE INVESTIGATIONS
SCALES AS NOTED
NOV. 6, 1930.
FILE G3.3WT

FIGURE 6



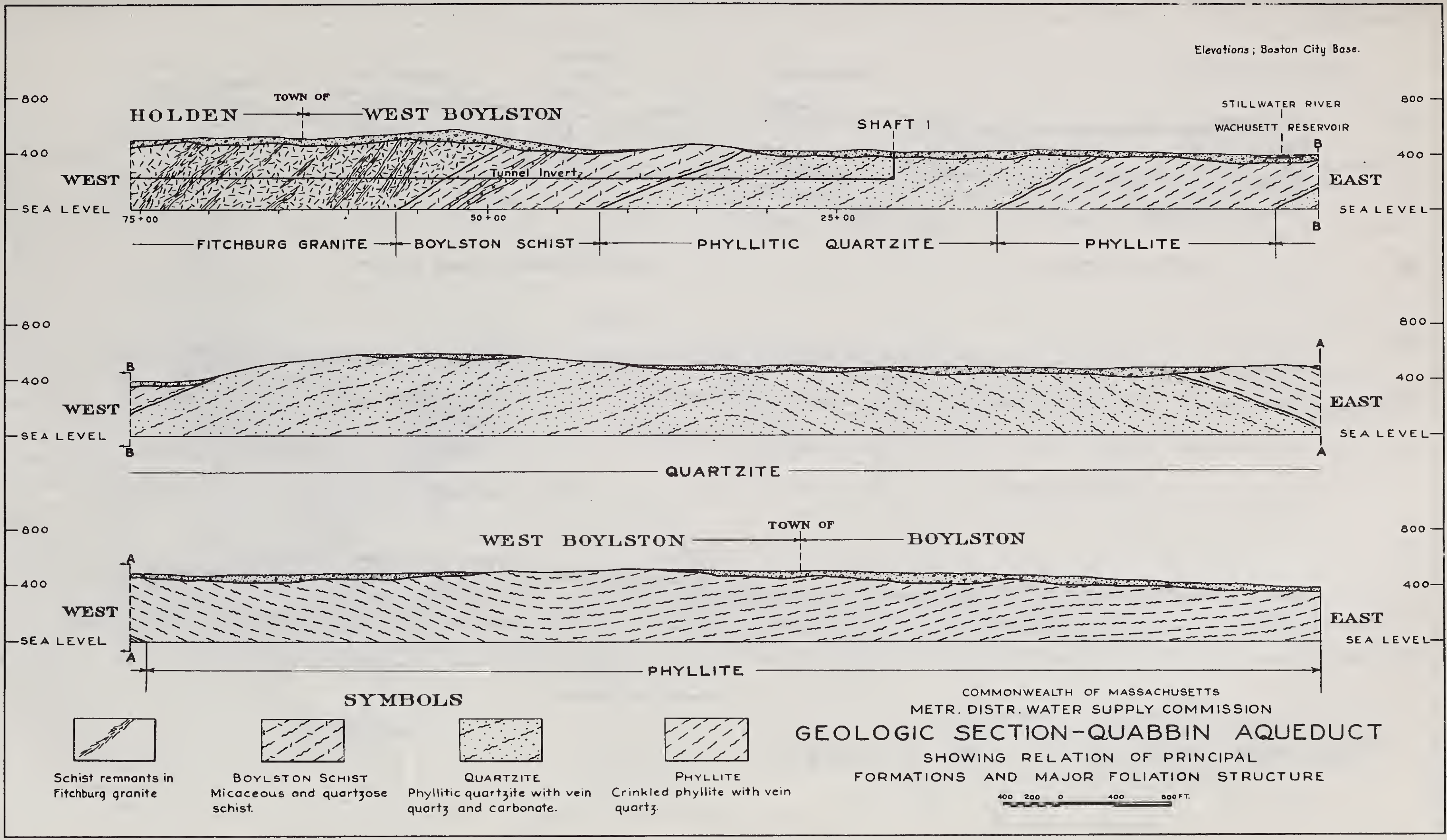
Note: The areal distribution of foundations, except for minor revisions, is essentially the same as that appearing on the PRELIMINARY MAP OF MASSACHUSETTS AND RHODE ISLAND by B.K. Emerson.

Note: Full extent of Dana diorite, forming border to Monson granodiorite not shown.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC MAP
JULY 17, 1934

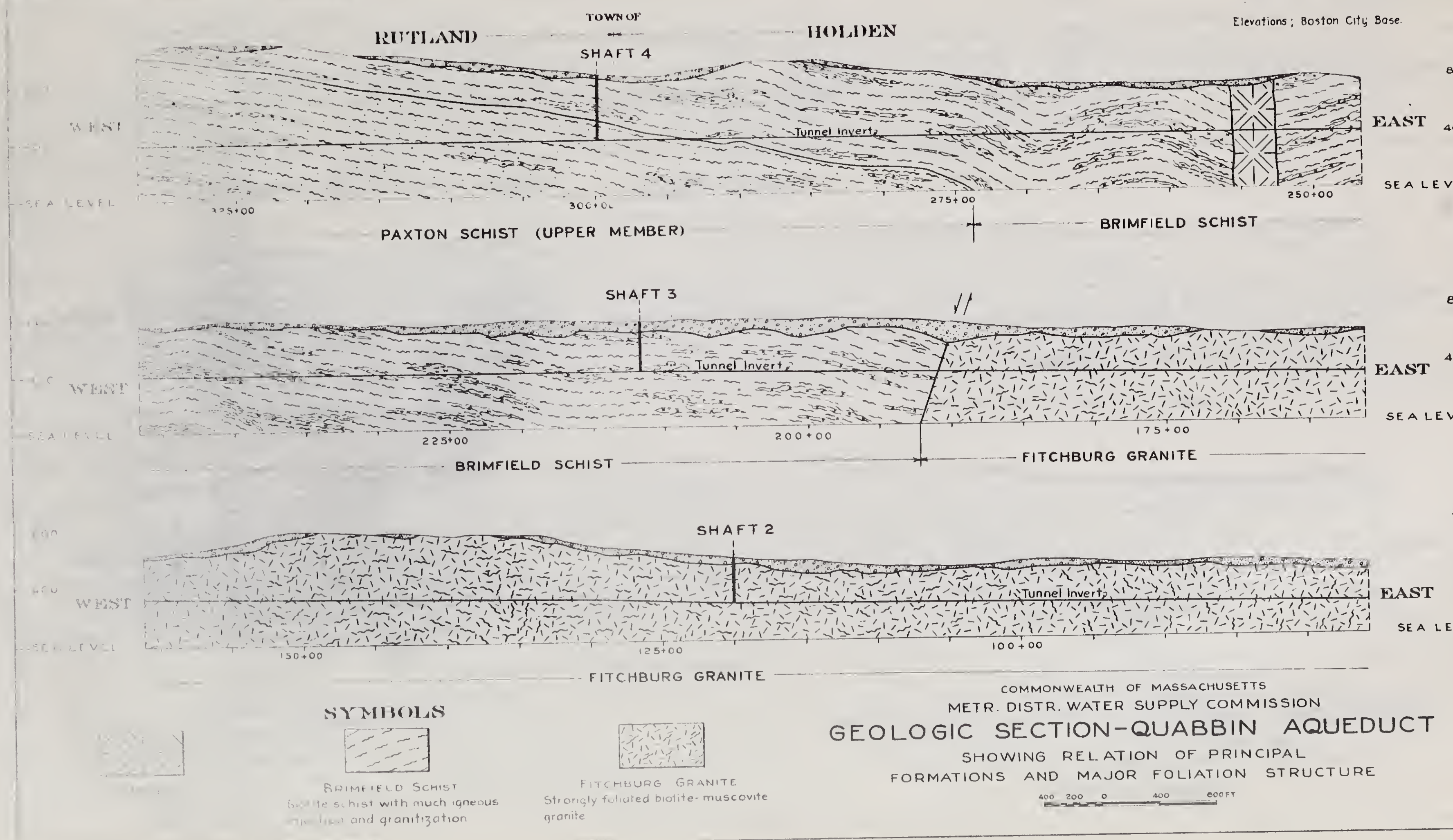
FIGURE 7

FIGURE 8A



COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
GEOLOGIC SECTION–QUABBIN AQUEDUCT
SHOWING RELATION OF PRINCIPAL
FORMATIONS AND MAJOR FOLIATION STRUCTURE

FIGURE 8B

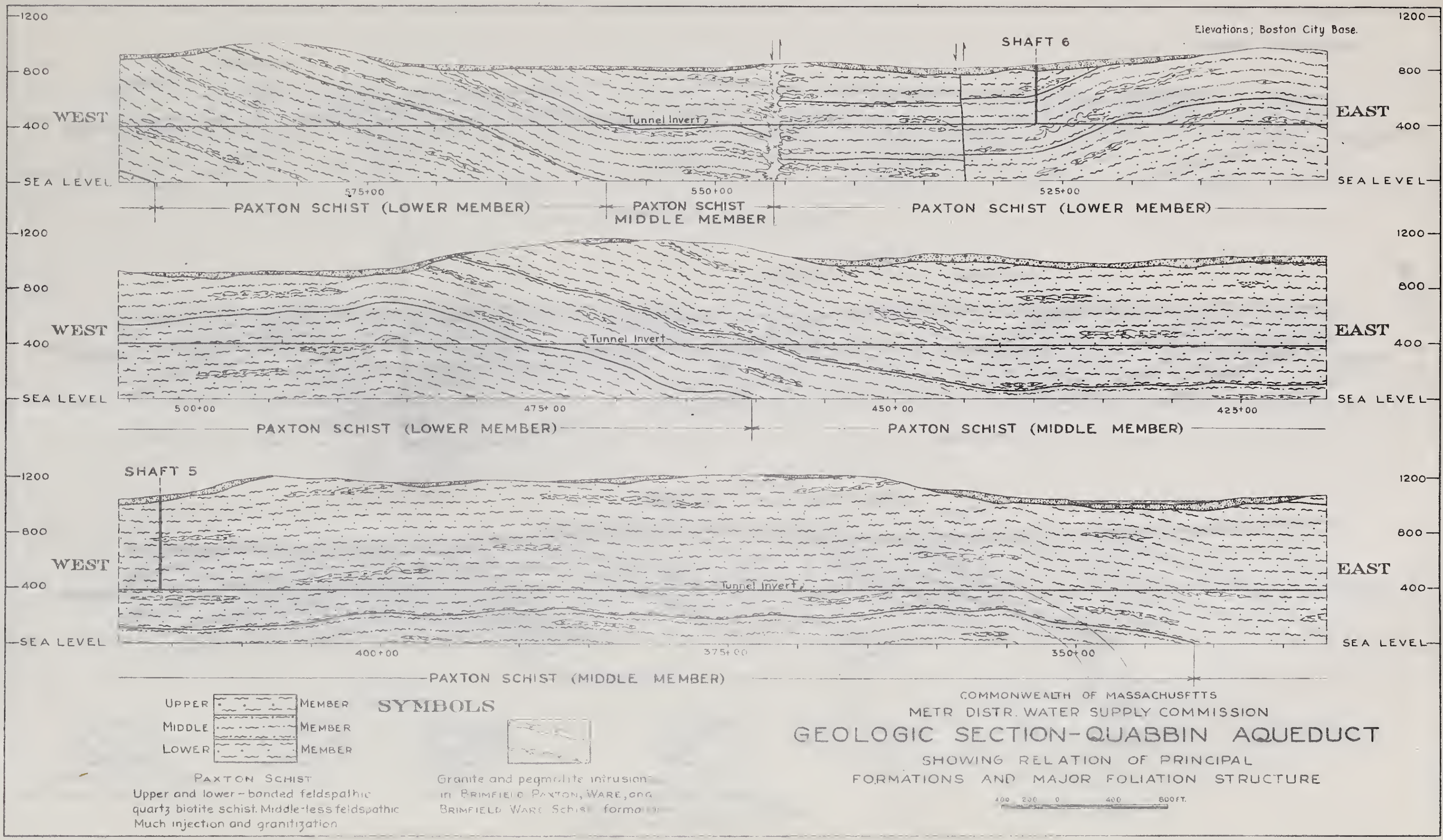


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

GEOLOGIC SECTION-QUABBIN AQUEDUCT

SHOWING RELATION OF PRINCIPAL
FORMATIONS AND MAJOR FOLIATION STRUCTURE

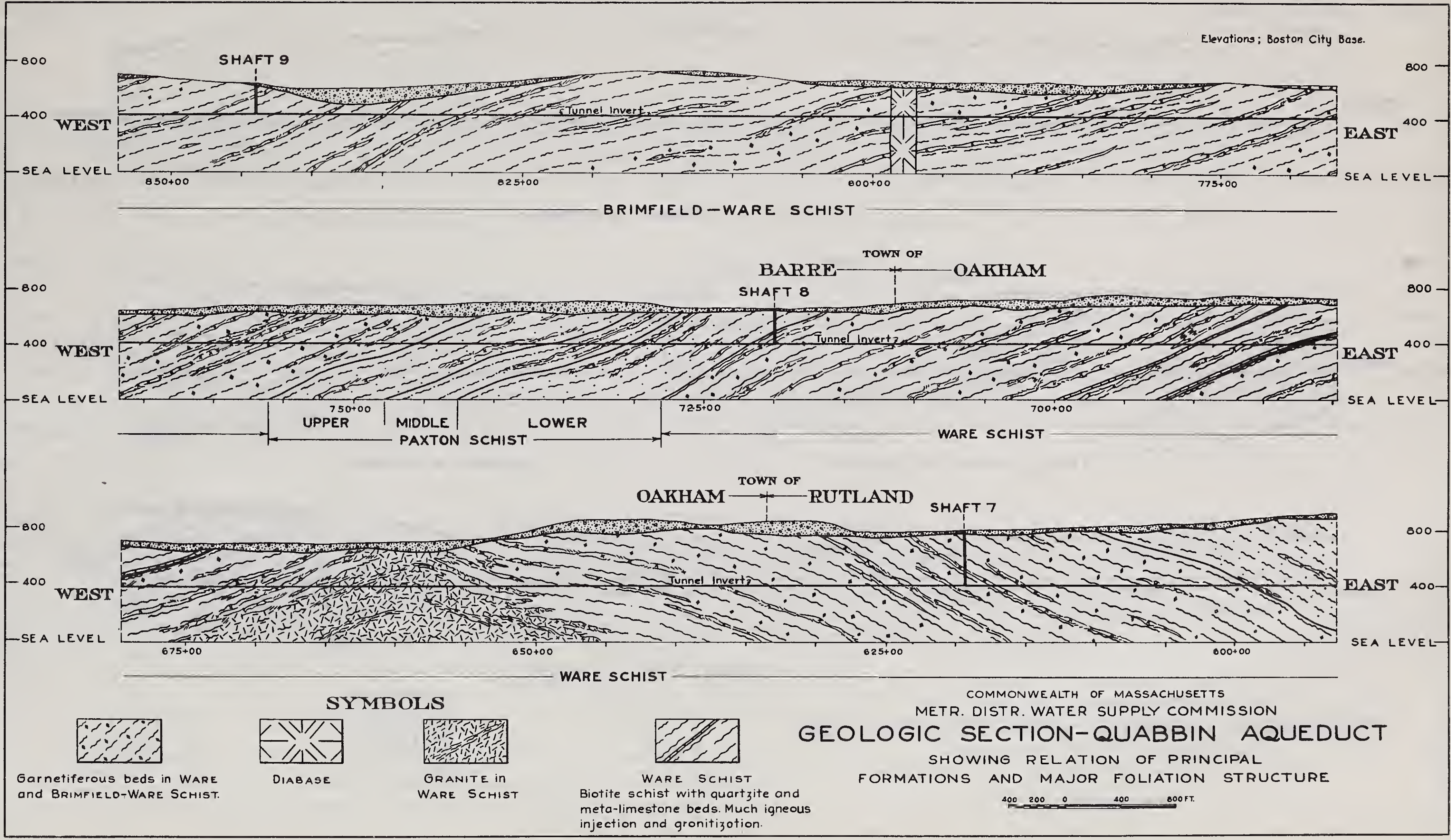
FIGURE 8c



COMMONWEALTH OF MASSACHUSETTS
METR DISTR. WATER SUPPLY COMMISSION
GEOLOGIC SECTION-QUABBIN AQUEDUCT
SHOWING RELATION OF PRINCIPAL
FORMATIONS AND MAJOR FOLIATION STRUCTURE

Elevations; Boston City Base.
1200
800
400
SEA LEVEL
WEST
EAST
SHAFT 6
SHAFT 5
Tunnel Invert
575+00
550+00
525+00
500+00
475+00
450+00
425+00
400+00
375+00
350+00
PAXTON SCHIST (LOWER MEMBER)
PAXTON SCHIST MIDDLE MEMBER
PAXTON SCHIST (MIDDLE MEMBER)
SYMBOLS
UPPER MEMBER
MIDDLE MEMBER
LOWER MEMBER
PAXTON SCHIST
Upper and lower - banded feldspathic quartz biotite schist. Middle-less feldspathic
Much injection and granitization
Granite and pegmatite intrusion in BRIMFIELD PAXTON, WARE, and BRIMFIELD WARE Schist formation
400 200 0 400 800 FT.

FIGURE 8D

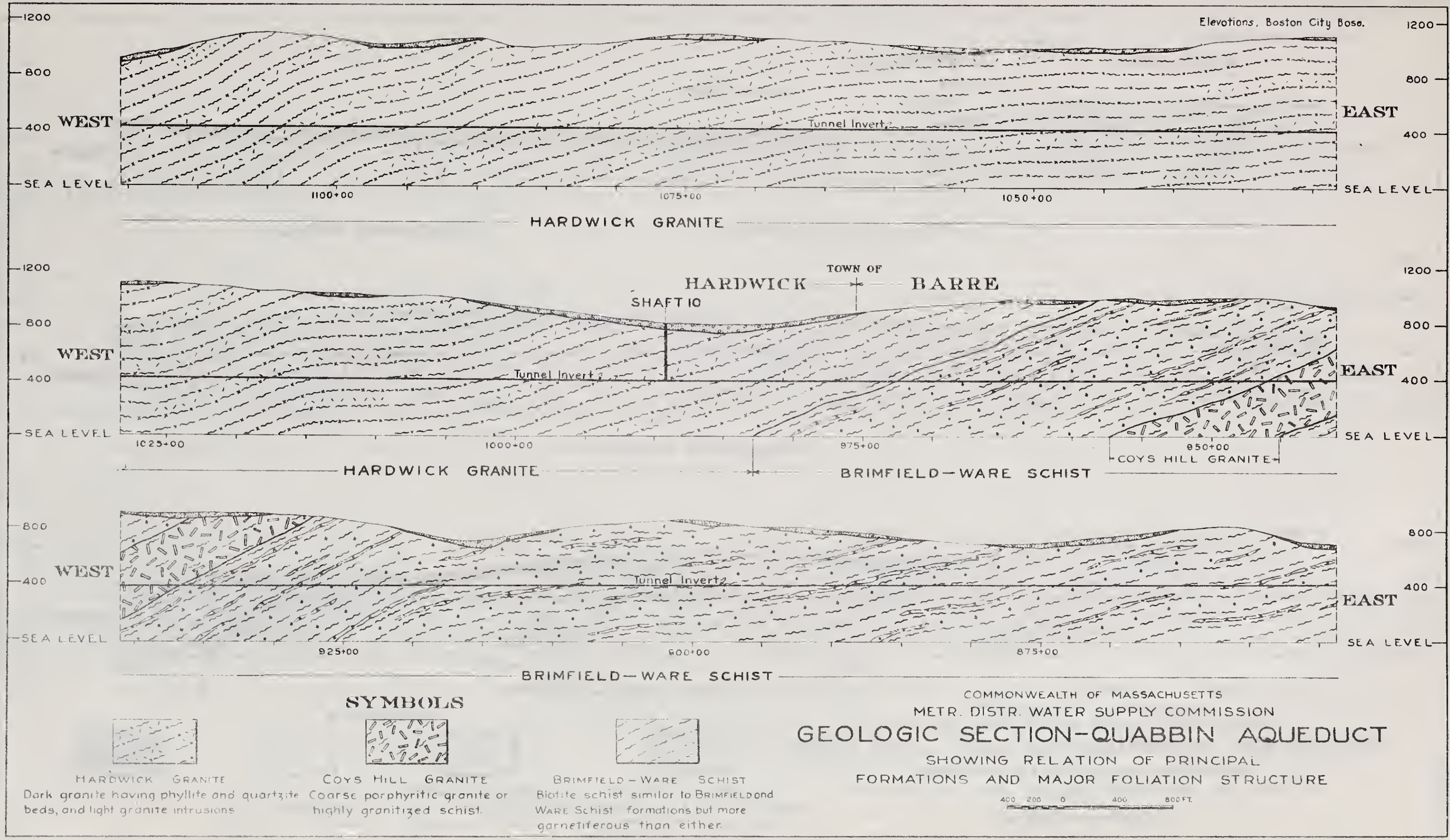


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

GEOLOGIC SECTION–QUABBIN AQUEDUCT

SHOWING RELATION OF PRINCIPAL FORMATIONS AND MAJOR FOLIATION STRUCTURE

FIGURE 8E

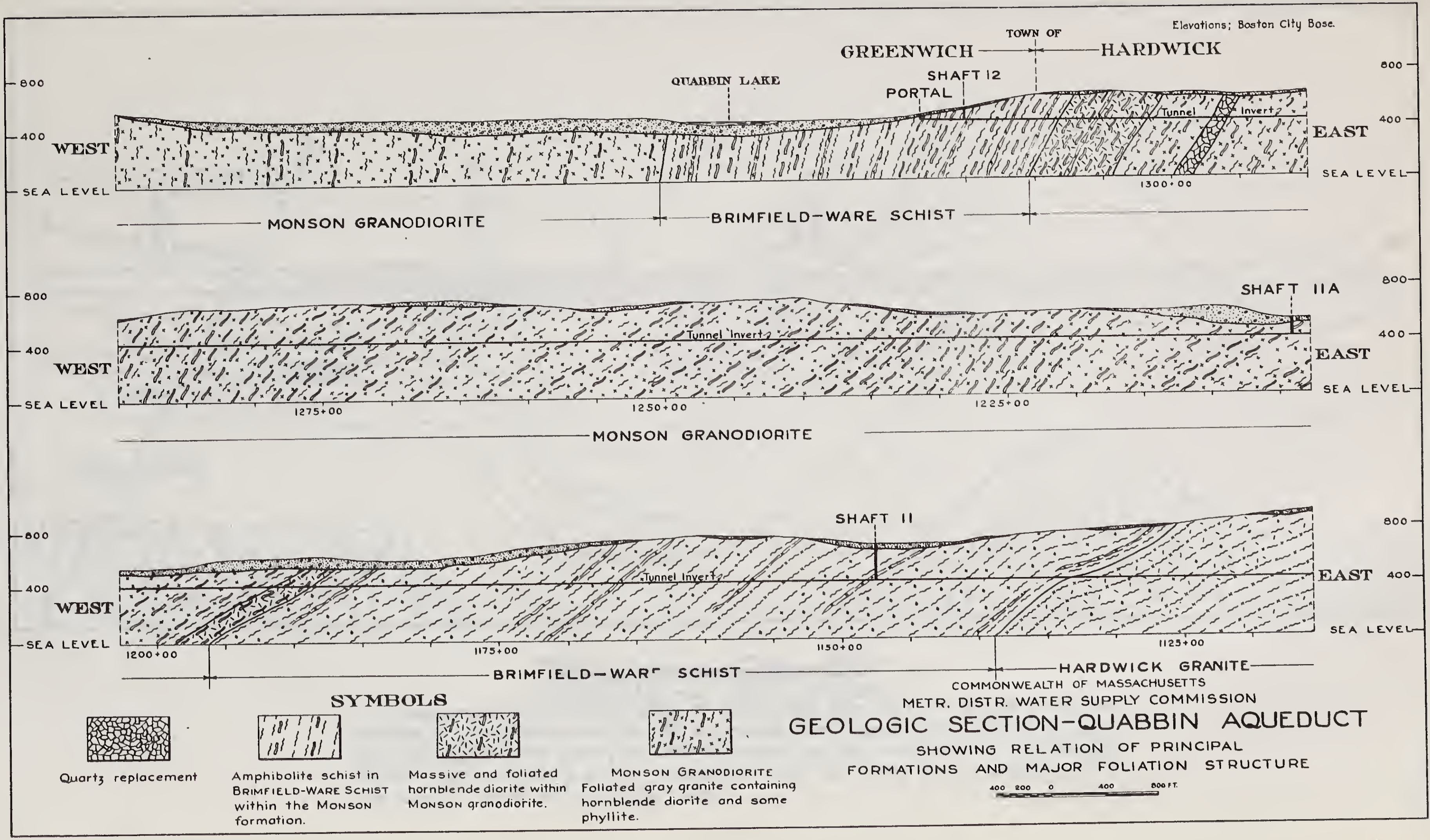


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

GEOLOGIC SECTION–QUABBIN AQUEDUCT

SHOWING RELATION OF PRINCIPAL
FORMATIONS AND MAJOR FOLIATION STRUCTURE

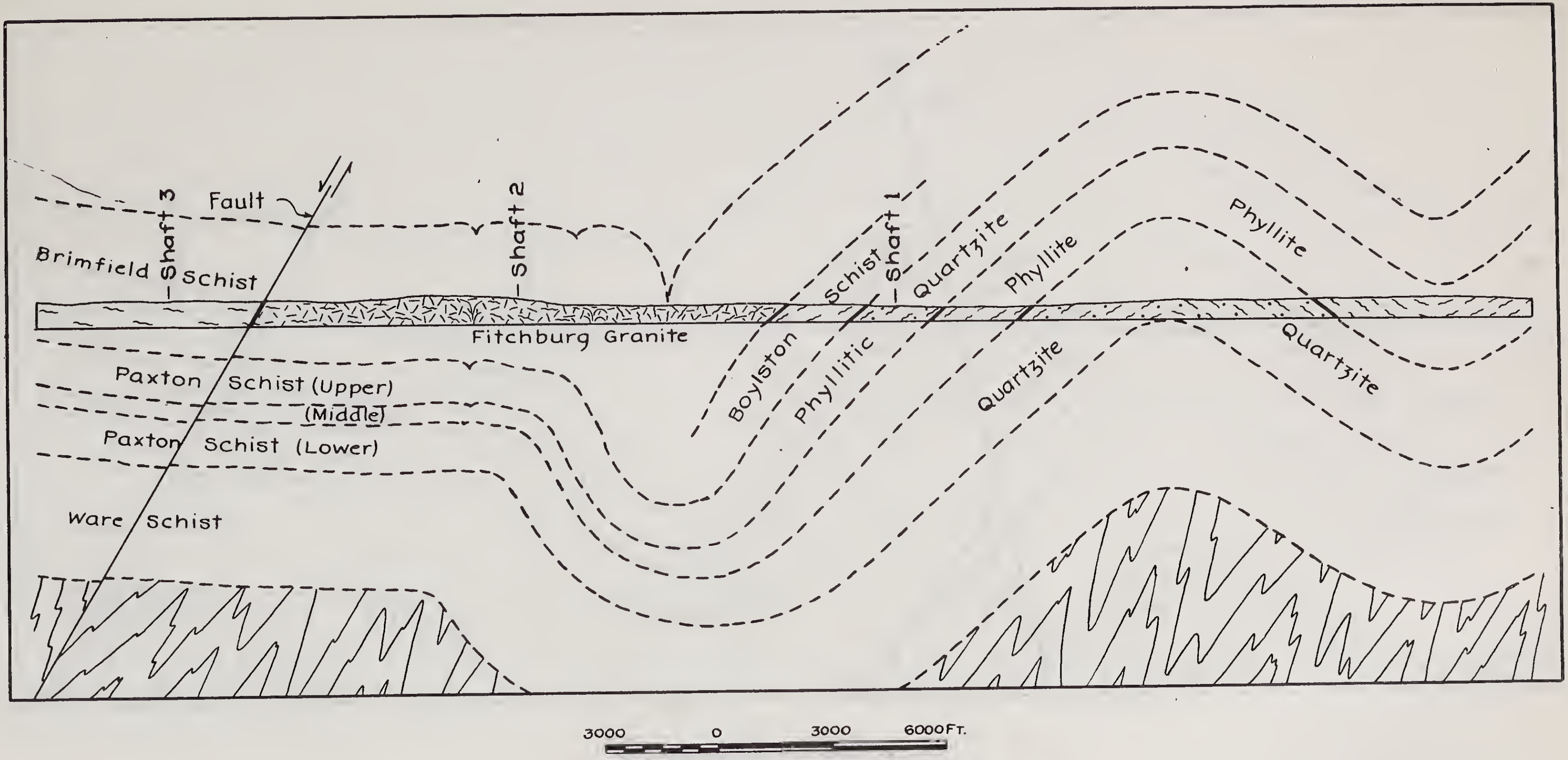
FIGURE 8F



COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

GEOLOGIC SECTION-QUABBIN AQUEDUCT
SHOWING RELATION OF PRINCIPAL
FORMATIONS AND MAJOR FOLIATION STRUCTURE

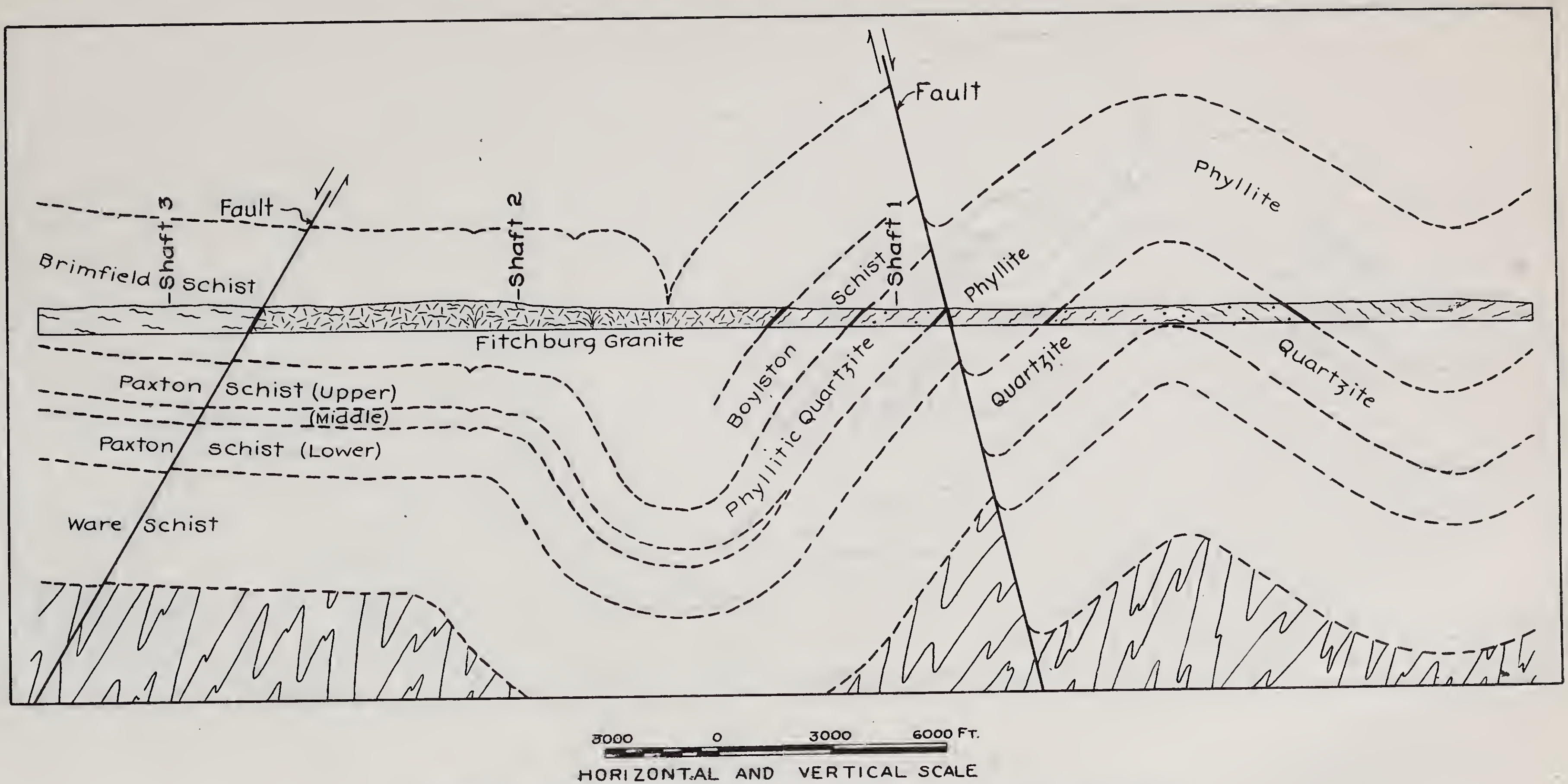
FIGURE 9



HORIZONTAL AND VERTICAL SCALE

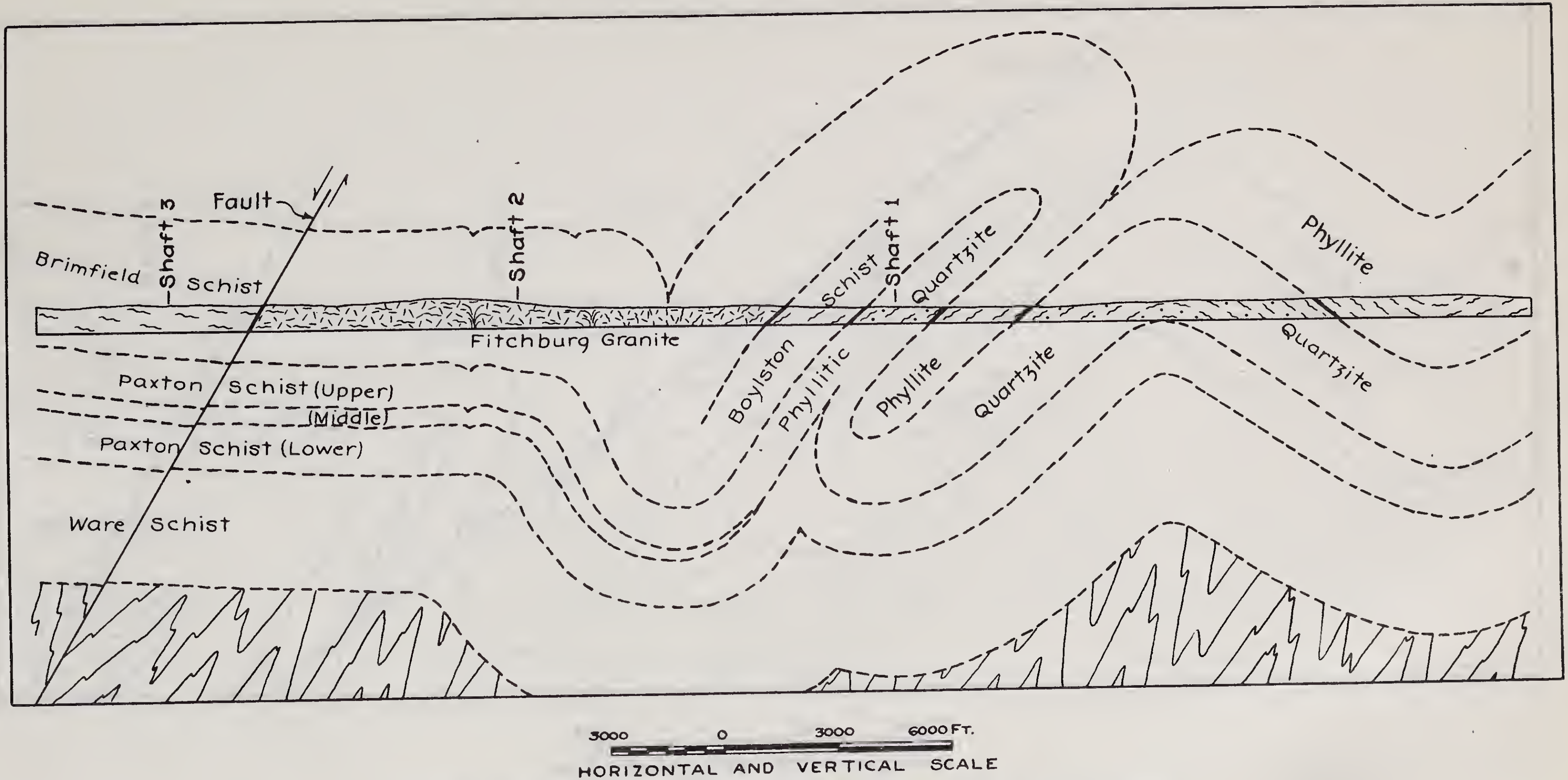
Diagramatic sketch illustrating an alternative interpretation of the structural attitude of formations based on the assumption that rocks are all of the same age; that the phyllite and quartzite of the geologic section are parts of the Worcester phyllite and Oakdale quartzite formations, and that they grade laterally into the schists, which occur farther west.

FIGURE 10



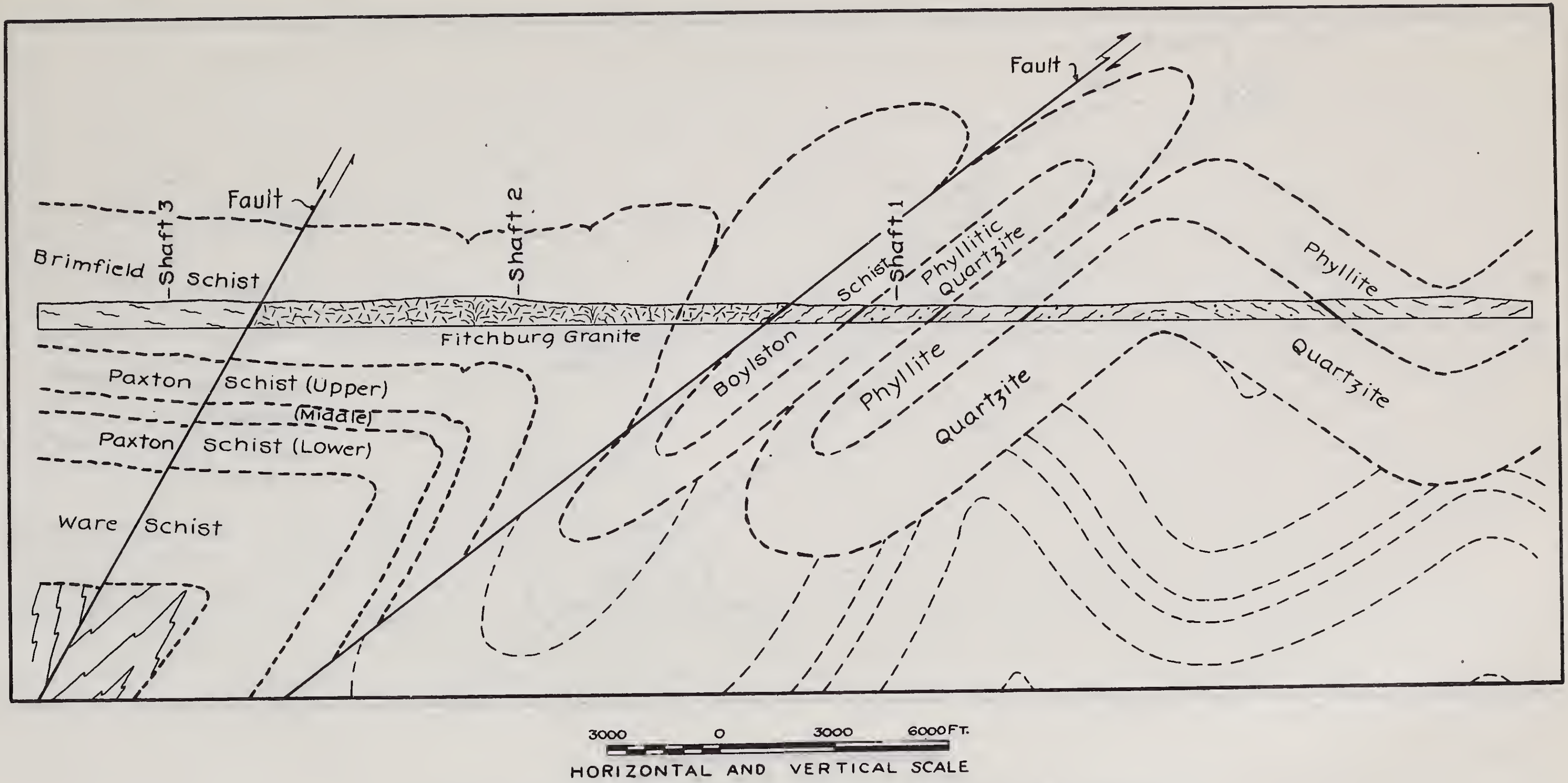
Diagramatic sketch or generalized section intended to illustrate an alternative interpretation of the stratigraphic relations based on the assumption that the formations are all of the same age; that phyllite and quartzite grade laterally into the schists which occur farther west, and that the whole series is normal faulted on the east.

FIGURE 11



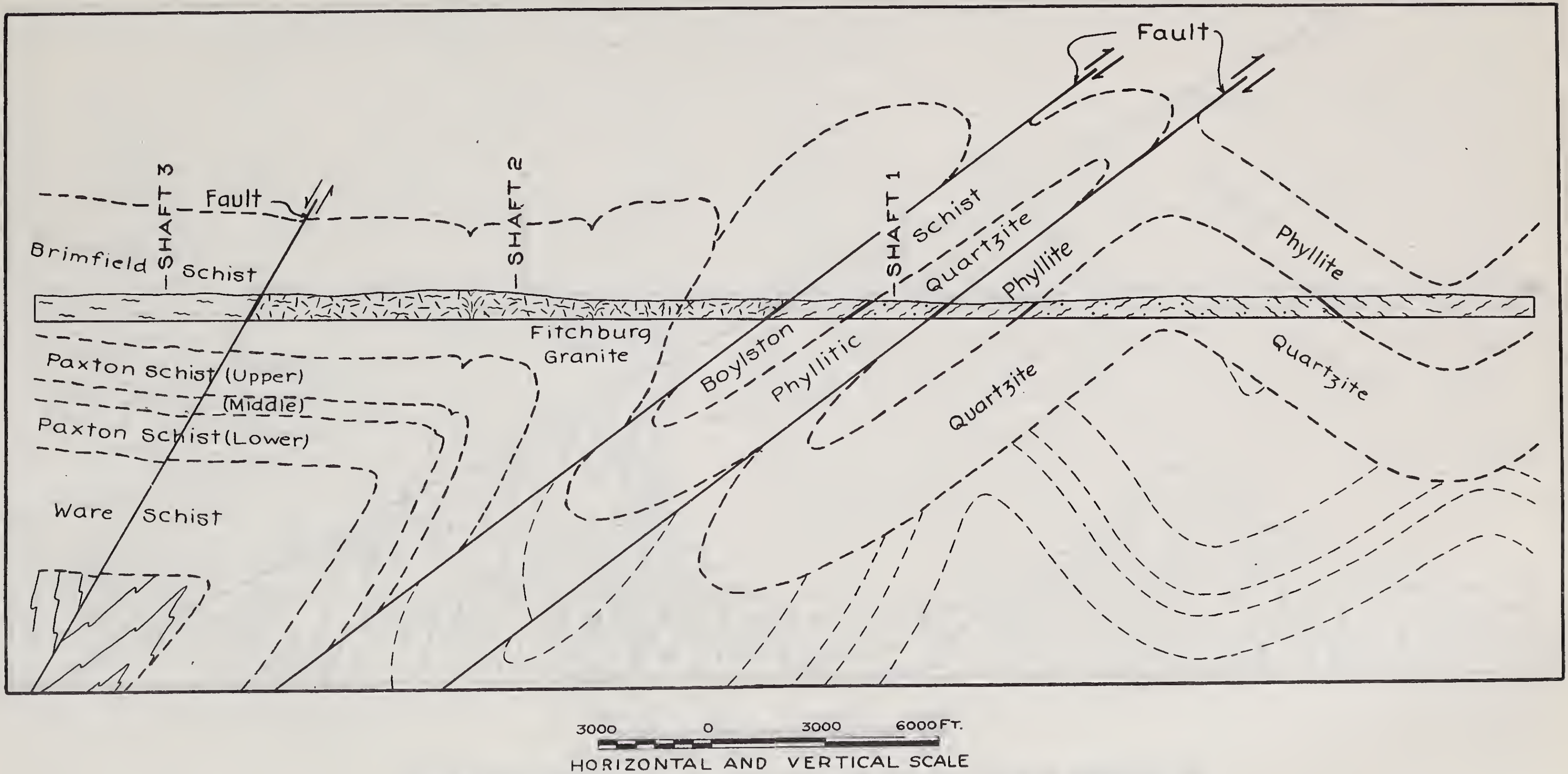
Diagromatic sketch showing an alternative interpretation of the stratigraphic relations of formations based on the assumption that the strata are of the same age and that their structural attitude is the result of close folding which preceded or accompanied the Fitchburg granite invasion.

FIGURE 12



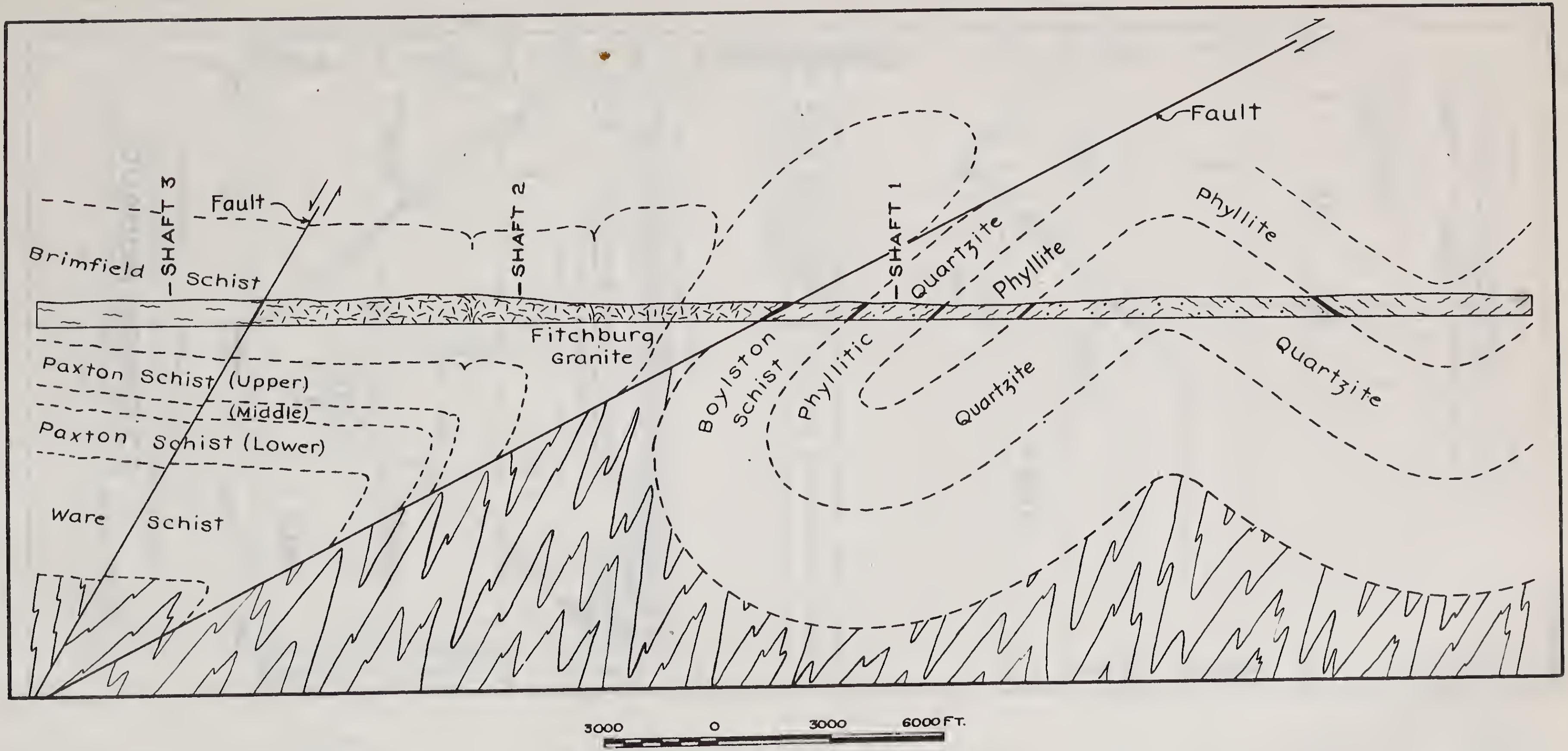
Generalized section showing the structural attitude drawn on the assumption that the schists are older than the phyllite and quartzite and have been displaced by thrust faulting. This interpretation regards the phyllite and quartzite as crowded, crumpled and overridden by the older schists. It is assumed that these movements preceded or were accompanied by the Fitchburg granite invasion which destroyed most of the structural evidence.

FIGURE 13



Diagramatic sketch showing an alternative interpretation of the structural relation of formations based on the assumption that the schist rocks of the western area represent a series of ancient sediments which have been thrust over the much younger phyllite and quartzite strata. This explanation differs only in the detail of faulting from the preceding.

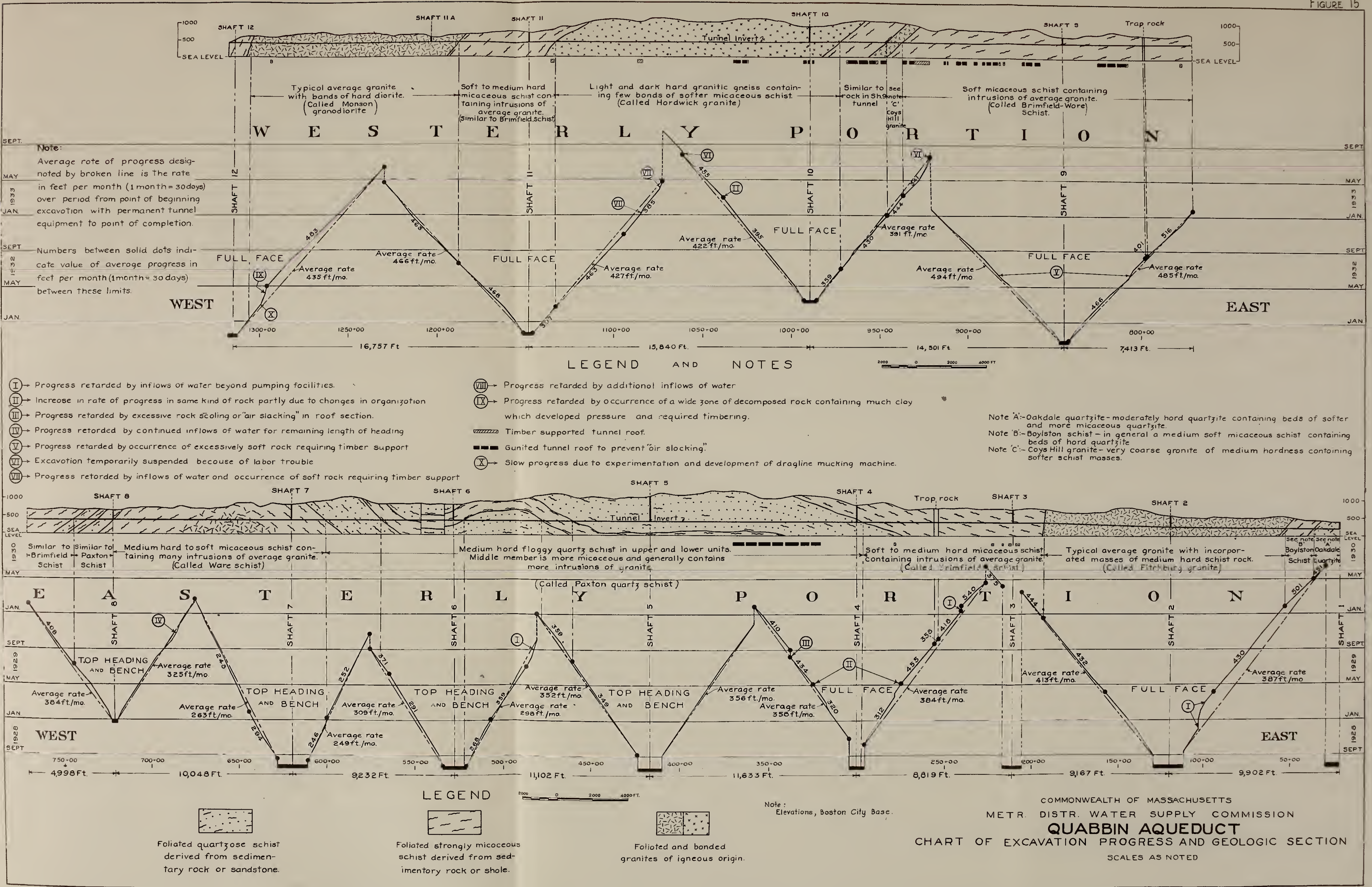
FIGURE 14



Diagramatic sketch showing an alternative interpretation based on different age relations for the Carboniferous phyllite of the Worcester "coal mine", the schists and the Fitchburg granite. The interpretation assumes that the schist strata were metamorphosed, deformed and intruded by granite before the Carboniferous period.

[illegible]

FIGURE 15



Note:
Average rate of progress designated by broken line is the rate in feet per month (1 month = 30 days) over period from point of beginning excavation with permanent tunnel equipment to point of completion.

Numbers between solid dots indicate value of average progress in feet per month (1 month = 30 days) between these limits.

LEGEND AND NOTES

Ⅰ→ Progress retarded by inflows of water beyond pumping facilities.
Ⅱ→ Increase in rate of progress in same kind of rock partly due to changes in organization
Ⅲ→ Progress retarded by excessive rock scaling or "air slacking" in roof section.
Ⅳ→ Progress retarded by continued inflows of water for remaining length of heading
Ⅴ→ Progress retarded by occurrence of excessively soft rock requiring timber support
Ⅵ→ Excavation temporarily suspended because of labor trouble
Ⅶ→ Progress retarded by inflows of water and occurrence of soft rock requiring timber support
Ⅷ→ Progress retarded by additional inflows of water
Ⅸ→ Progress retarded by occurrence of a wide zone of decomposed rock containing much clay which developed pressure and required timbering.
▨ Timber supported tunnel roof.
▬ ▬ ▬ Gunited tunnel roof to prevent "air slacking."
Ⅹ→ Slow progress due to experimentation and development of dragline mucking machine.

Note 'A':- Oakdale quartzite - moderately hard quartzite containing beds of softer and more micaceous quartzite.
Note 'B':- Boylston schist - in general a medium soft micaceous schist containing beds of hard quartzite
Note 'C':- Coys Hill granite - very coarse granite of medium hardness containing softer schist masses.

LEGEND

Foliated quartzose schist derived from sedimentary rock or sandstone.

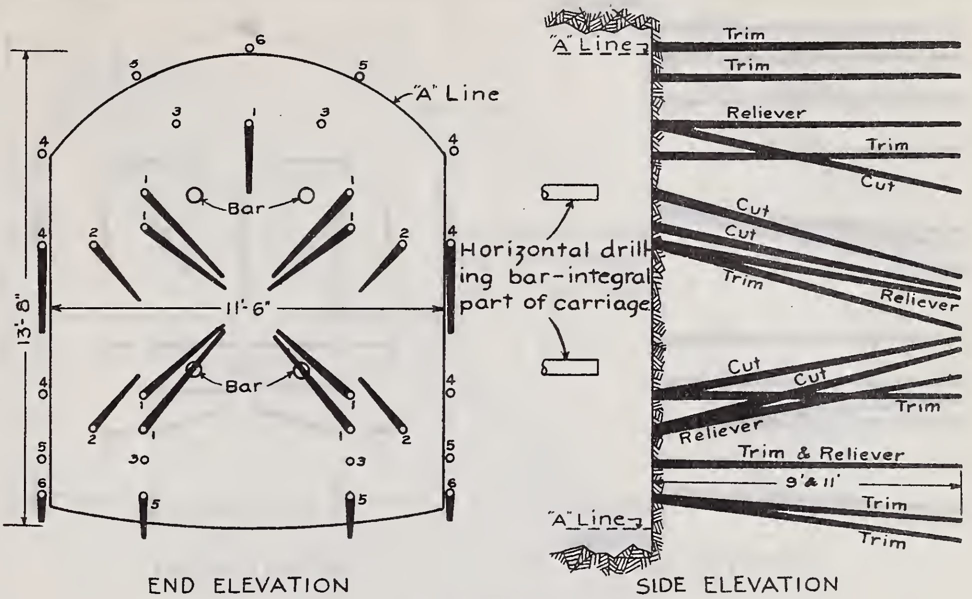
Foliated strongly micaceous schist derived from sedimentary rock or shale.

Foliated and banded granites of igneous origin.

Note:
Elevations, Boston City Base.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
CHART OF EXCAVATION PROGRESS AND GEOLOGIC SECTION
SCALES AS NOTED

FIGURE 16

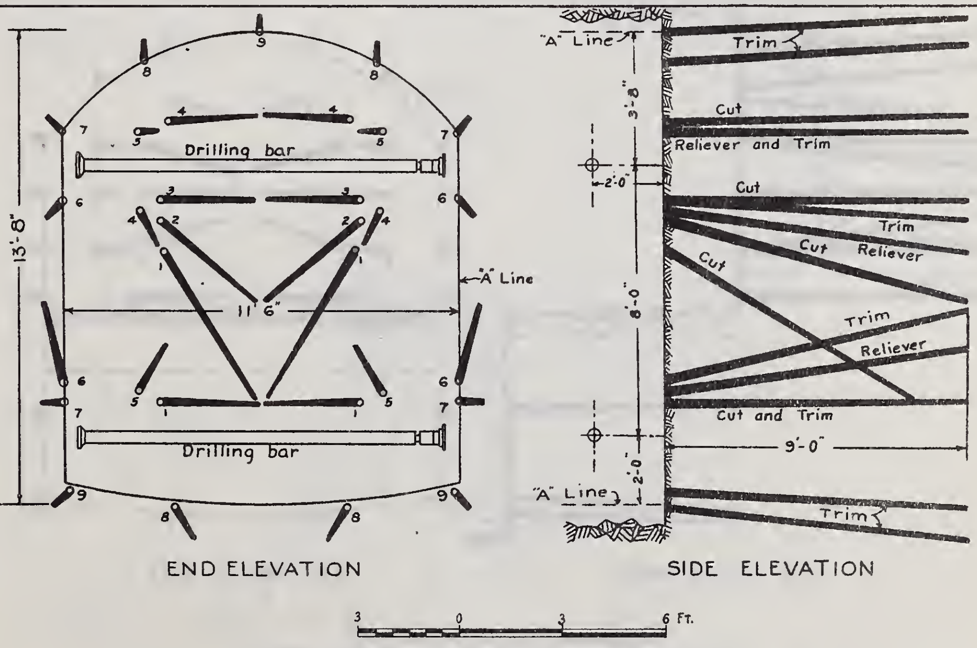


END ELEVATION SIDE ELEVATION

The numbers indicate the order of firing by delayed timing.

DIAGRAM SHOWING LOCATION OF DRILL HOLES IN FULL HEADINGS AT SHAFT 11

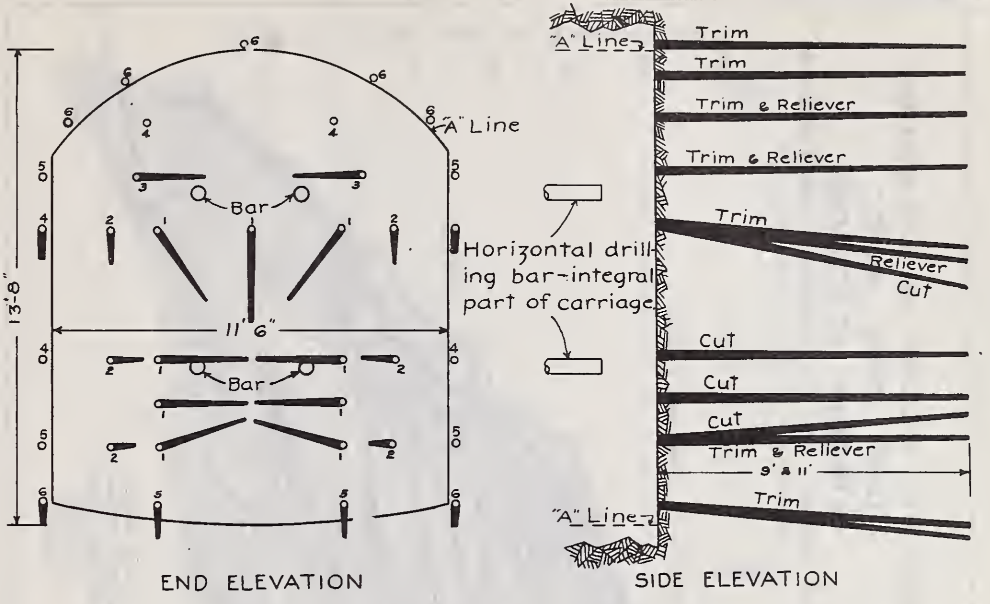
16b



END ELEVATION SIDE ELEVATION

DIAGRAM SHOWING LOCATION OF DRILL HOLES IN FULL HEADINGS AT SHAFT 2

FIGURE 17



The numbers indicate the order of firing by delayed timing.
DIAGRAM SHOWING LOCATION OF DRILL HOLES IN FULL HEADINGS AT SHAFT 12

17b

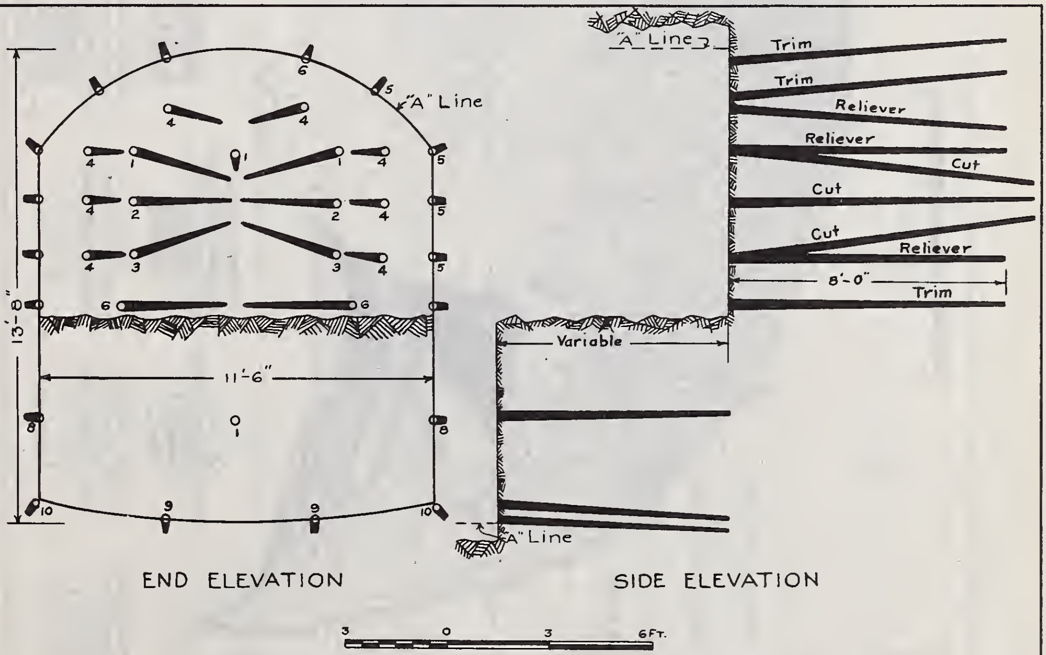
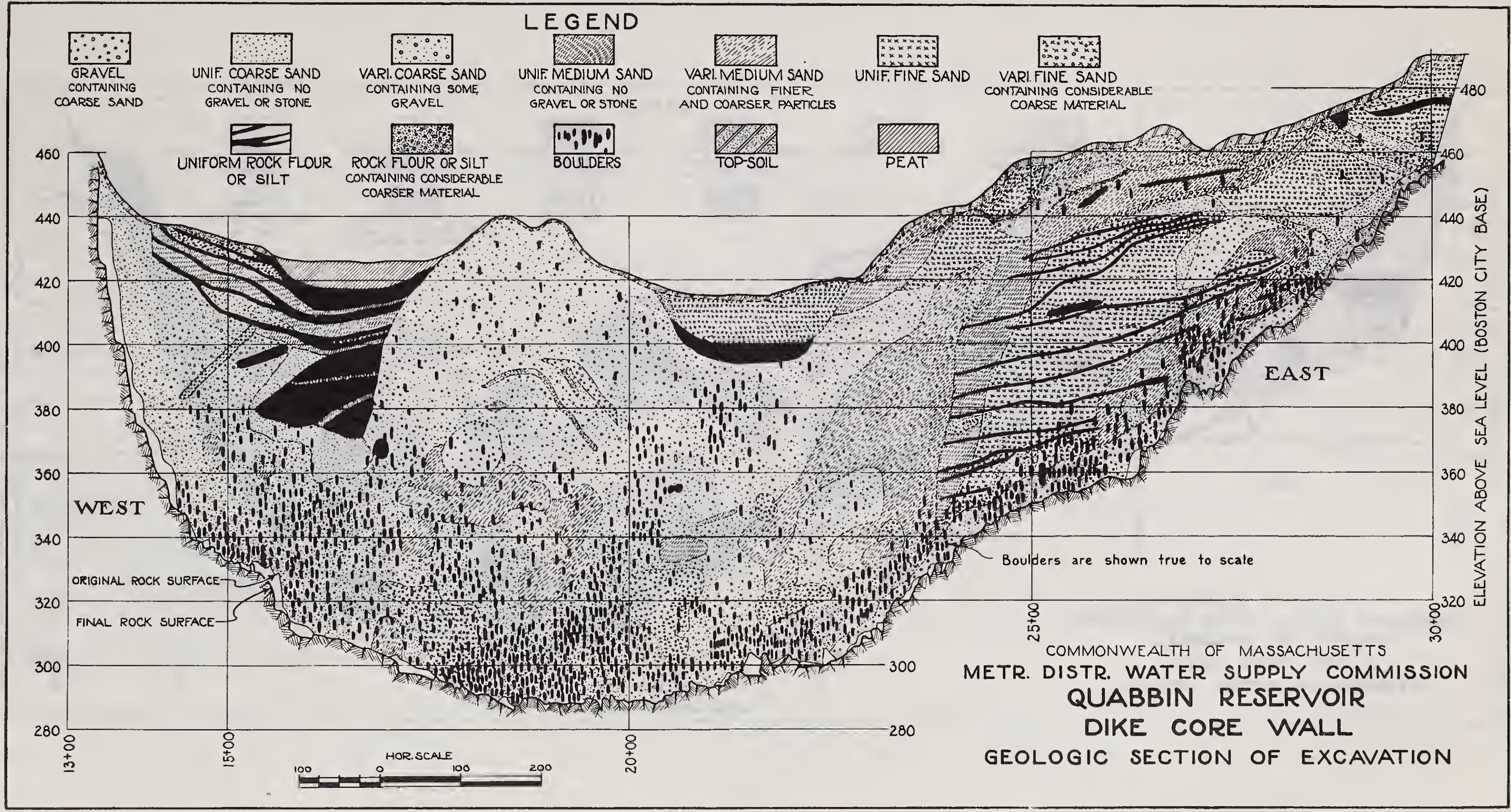


DIAGRAM SHOWING LOCATION OF DRILL HOLES IN THE TOP HEAD AND BENCH, TYPICAL FOR SHAFTS 5-8

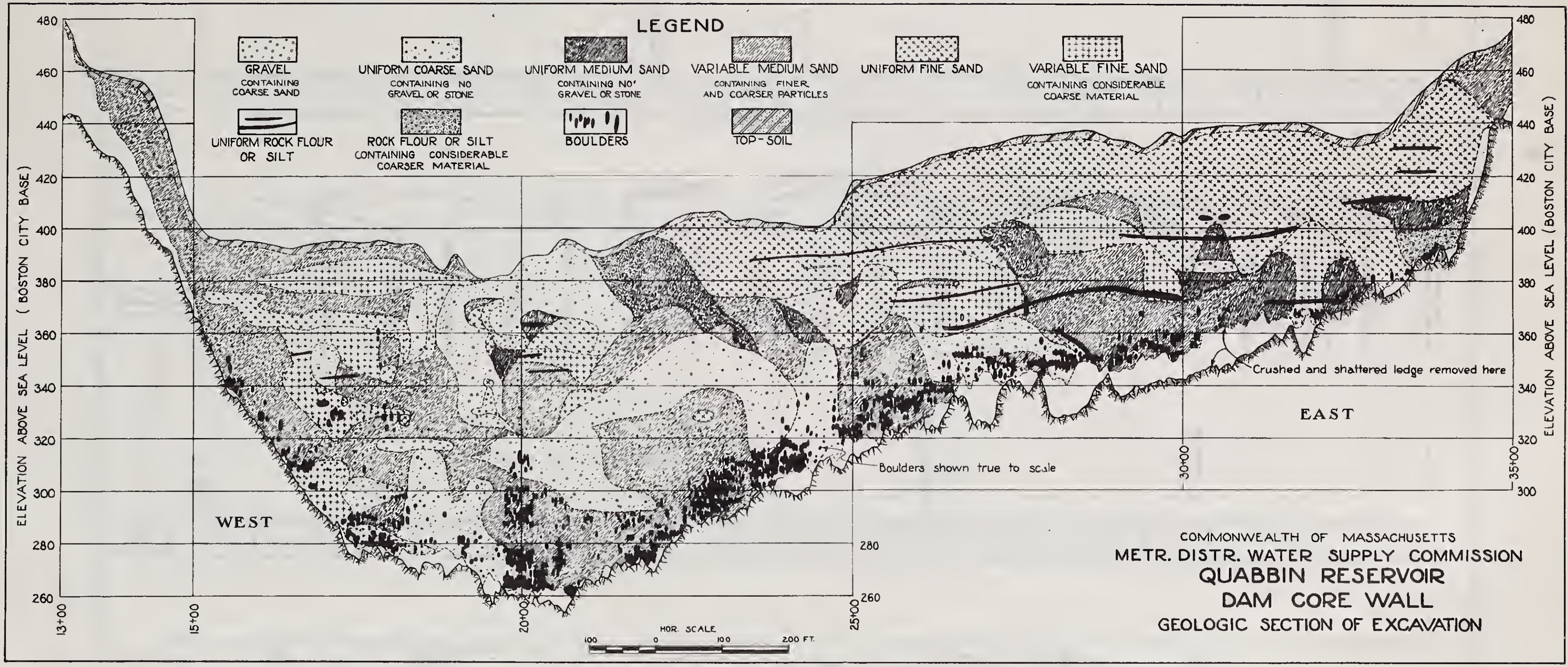
FIGURE 18

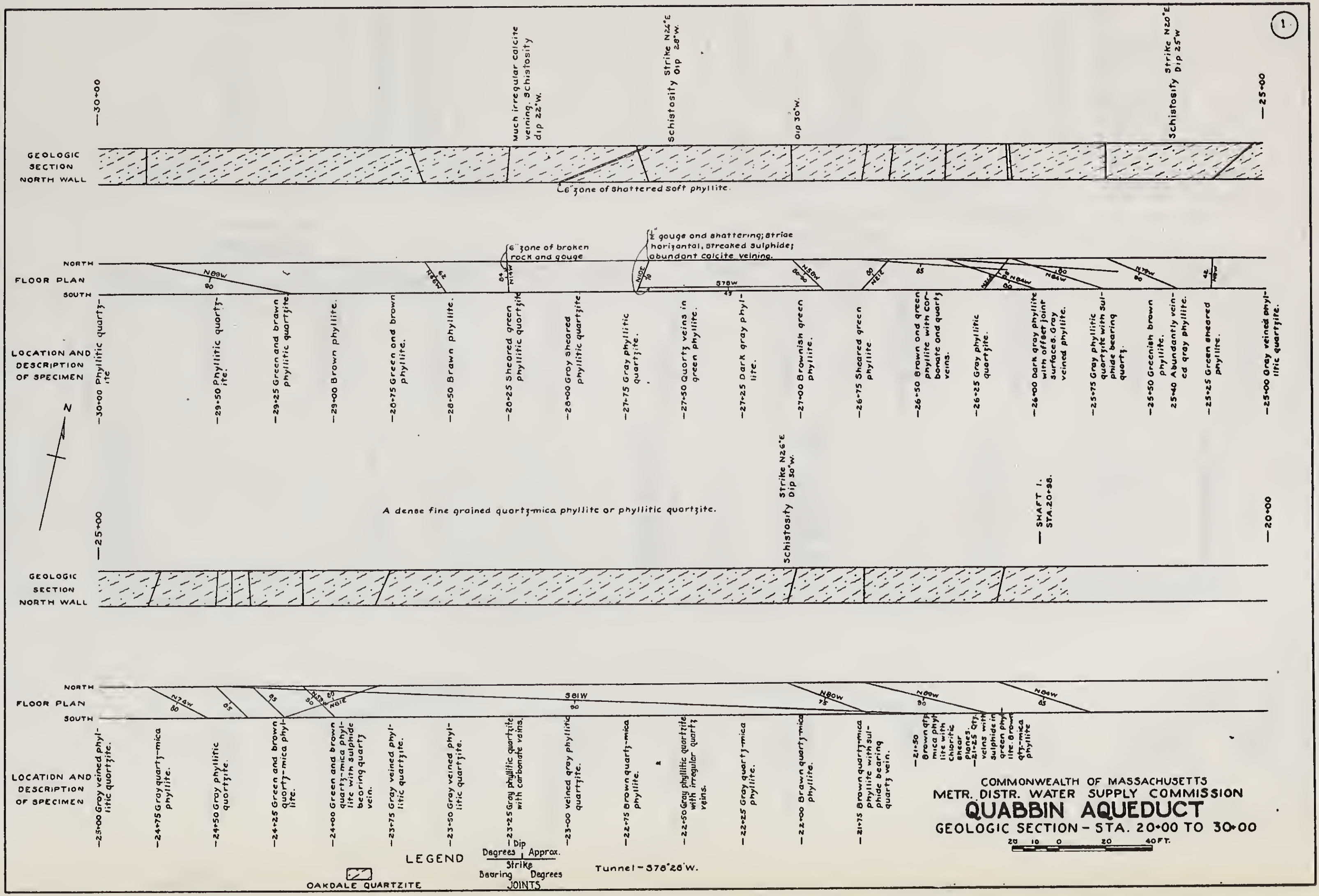


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN RESERVOIR
DIKE CORE WALL
GEOLOGIC SECTION OF EXCAVATION

LEGEND
GRAVEL CONTAINING COARSE SAND
UNIF. COARSE SAND CONTAINING NO GRAVEL OR STONE
VARI. COARSE SAND CONTAINING SOME GRAVEL
UNIF. MEDIUM SAND CONTAINING NO GRAVEL OR STONE
VARI. MEDIUM SAND CONTAINING FINER AND COARSER PARTICLES
UNIF. FINE SAND
VARI. FINE SAND CONTAINING CONSIDERABLE COARSE MATERIAL
UNIFORM ROCK FLOUR OR SILT
ROCK FLOUR OR SILT CONTAINING CONSIDERABLE COARSER MATERIAL
BOULDERS
TOP-SOIL
PEAT
WEST
EAST
ORIGINAL ROCK SURFACE
FINAL ROCK SURFACE
Boulders are shown true to scale
ELEVATION ABOVE SEA LEVEL (BOSTON CITY BASE)
460
440
420
400
380
360
340
320
300
280
480
13+00
15+00
20+00
25+00
30+00
HOR. SCALE
100
0
100
200

FIGURE 19

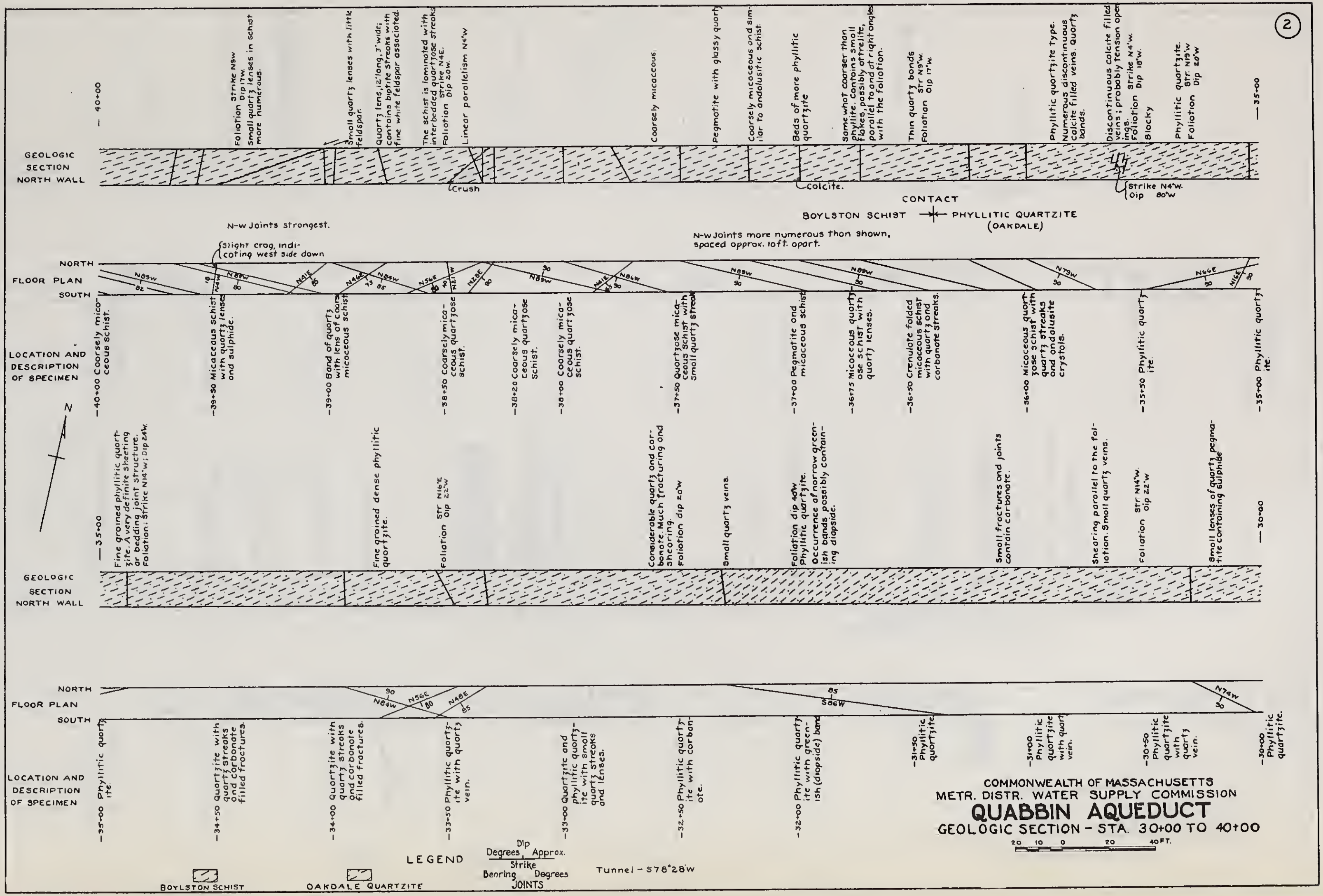

LEGEND
GRAVEL CONTAINING COARSE SAND
UNIFORM COARSE SAND CONTAINING NO GRAVEL OR STONE
UNIFORM MEDIUM SAND CONTAINING NO GRAVEL OR STONE
VARIABLE MEDIUM SAND CONTAINING FINER AND COARSER PARTICLES
UNIFORM FINE SAND
VARIABLE FINE SAND CONTAINING CONSIDERABLE COARSE MATERIAL
UNIFORM ROCK FLOUR OR SILT
ROCK FLOUR OR SILT CONTAINING CONSIDERABLE COARSER MATERIAL
BOULDERS
TOP-SOIL
ELEVATION ABOVE SEA LEVEL (BOSTON CITY BASE)
480
460
440
420
400
380
360
340
320
300
280
260
13+00
15+00
20+00
25+00
30+00
35+00
WEST
EAST
Crushed and shattered ledge removed here
Boulders shown true to scale
HOR. SCALE
100
0
100
200 FT.
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN RESERVOIR
DAM CORE WALL
GEOLOGIC SECTION OF EXCAVATION


①
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
—30+00
—25+00
—20+00
Much irregular calcite veining. Schistosity dip 22°W.
Schistosity Strike N26°E Dip 28°W.
Dip 30°W.
Schistosity Strike N20°E Dip 25°W
6" zone of shattered soft phyllite.
6" zone of broken rock and gouge
½" gouge and shattering; striae horizontal, streaked sulphide; abundant calcite veining.
N88W 80
N30W 62
N14W 84
N10E 70
S78W 43
N50W 80-90
N21E 80
85
N64W 80
N84W 100
N79W 80
N8W 42
—30+00 Phyllitic quartzite
—29+50 Phyllitic quartzite.
—29+25 Green and brown phyllitic quartzite
—29+00 Brown phyllite.
—28+75 Green and brown phyllite.
—28+50 Brown phyllite.
—28+25 Sheared green phyllitic quartzite
—28+00 Gray sheared phyllitic quartzite
—27+75 Gray phyllitic quartzite.
—27+50 Quartz veins in green phyllite.
—27+25 Dark gray phyllite.
—27+00 Brownish green phyllite.
—26+75 Sheared green phyllite
—26+50 Brown and green phyllite with carbonate and quartz veins.
—26+25 Gray phyllitic quartzite.
—26+00 Dark gray phyllite with offset joint surfaces. Gray veined phyllite.
—25+75 Gray phyllitic quartzite with sulphide bearing quartz.
—25+50 Greenish brown phyllite.
25+40 Abundantly veined gray phyllite.
—25+25 Green sheared phyllite.
—25+00 Gray veined phyllitic quartzite.
A dense fine grained quartz-mica phyllite or phyllitic quartzite.
Schistosity Strike N26°E Dip 30°W.
— SHAFT 1. STA. 20+98.
N74W 80
85
85
N53W 80
80
N61E
S81W 90
N80W 75
N60W 90
N64W 85
—25+00 Gray veined phyllitic quartzite.
—24+75 Gray quartz-mica phyllite.
—24+50 Gray phyllitic quartzite.
—24+25 Green and brown quartz-mica phyllite.
—24+00 Green and brown quartz-mica phyllite with sulphide bearing quartz vein.
—23+75 Gray veined phyllitic quartzite.
—23+50 Gray veined phyllitic quartzite.
—23+25 Gray phyllitic quartzite with carbonate veins.
—23+00 veined gray phyllitic quartzite.
—22+75 Brown quartz-mica phyllite.
—22+50 Gray phyllitic quartzite with irregular quartz veins.
—22+25 Gray quartz-mica phyllite.
—22+00 Brown quartz-mica phyllite.
—21+75 Brown quartz-mica phyllite with sulphide bearing quartz vein.
—21+50 Brown qtz. mica phyllite with chloritic shear planes.
—21+25 Qtz. veins with sulphide in green phyllite. Brown qtz.-mica phyllite
LEGEND
OAKDALE QUARTZITE
Dip Degrees Approx. Strike Bearing Degrees
JOINTS
Tunnel – S78°26'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

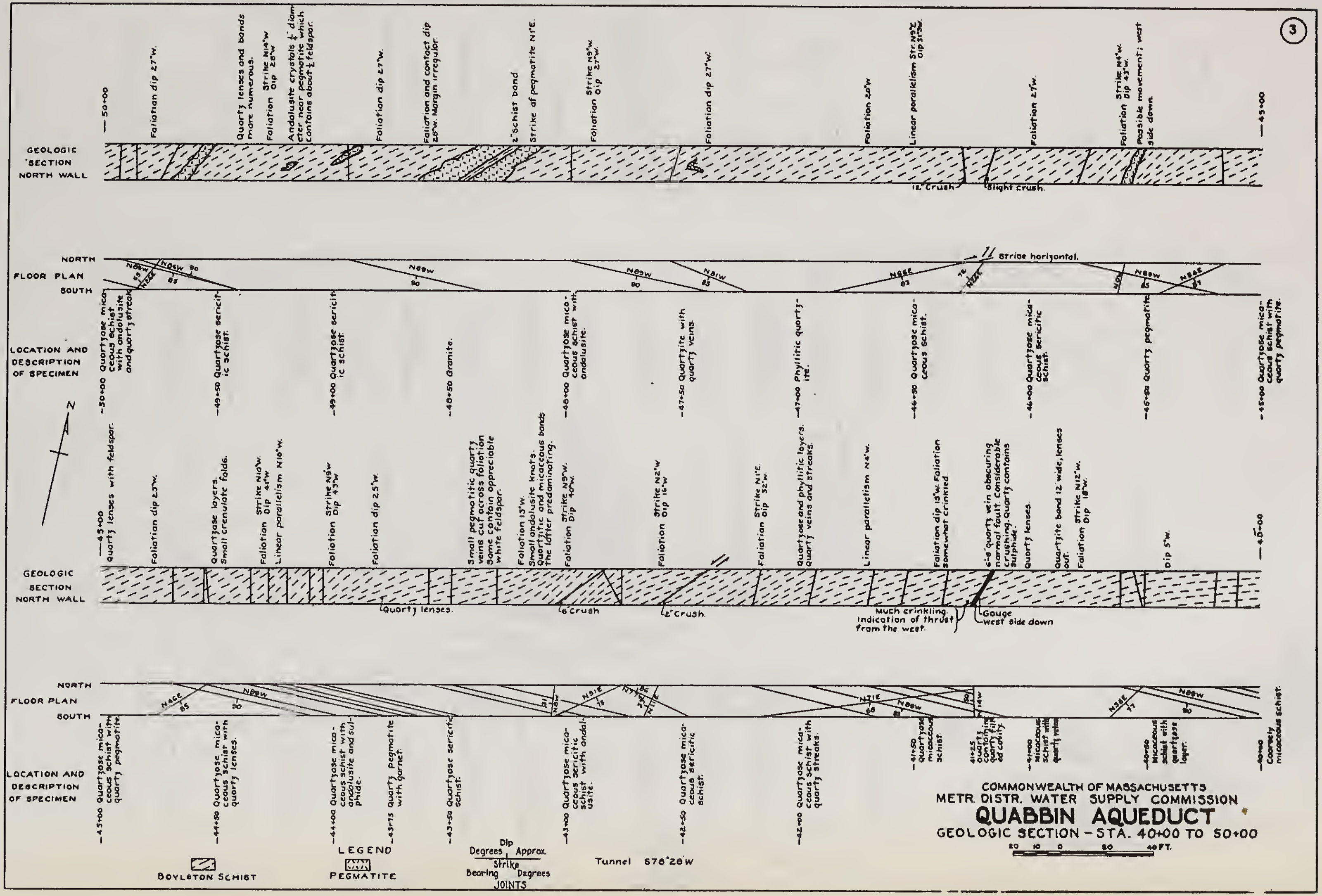
GEOLOGIC SECTION – STA. 20+00 TO 30+00


②
40+00
35+00
30+00
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
Foliation Strike N9W Dip 17W. Small quartz lenses in schist more numerous.
Small quartz lenses with little feldspar.
Quartz lens, 12' long, 3' wide; contains biotite streaks with fine white feldspar associated.
The schist is laminated with interbedded quartzose streaks. Foliation Strike N4E. Dip 20W.
Linear parallelism N4°W
Crush
Coarsely micaceous.
Pegmatite with glassy quartz
Coarsely micaceous and similar to andalusitic schist.
Beds of more phyllitic quartzite
Calcite.
Somewhat coarser than phyllite. Contains small flakes, possibly ottrelite, parallel to and at right angles with the foliation.
Thin quartz bands. Foliation Str N9°W. Dip 17°W.
Phyllitic quartzite type. Numerous discontinuous calcite filled veins. Quartz bands.
Discontinuous calcite filled veins; probably tension openings. Foliation Strike N4°W. Dip 18°W.
Blocky
Phyllitic quartzite. Foliation Str. N19°W Dip 20°W
Strike N4°W. Dip 80°W
CONTACT
BOYLSTON SCHIST → ← PHYLLITIC QUARTZITE (OAKDALE)
N-W Joints strongest.
Slight crag, indicating west side down
N-W Joints more numerous than shown, spaced approx. 10 ft. apart.
N83W 82
N4W 10
N87W 80
N41E 85
N46E 73
N84W 85
N56E 80
N21E 40
N28E 80
N83W 90
N41E 30
N86W
N83W 90
N89W 90
N79W 90
N66E 90
N16E 90
—40+00 Coarsely micaceous schist.
—39+50 Micaceous schist with quartz lenses and sulphide.
—39+00 Band of quartz with lens of coarse micaceous schist.
—38+50 Coarsely micaceous quartzose schist.
—38+20 Coarsely micaceous quartzose schist.
—38+00 Coarsely micaceous quartzose schist.
—37+50 Quartzose micaceous schist with small quartz streaks
—37+00 Pegmatite and micaceous schist
—36+75 Micaceous quartzose schist with quartz lenses.
—36+50 Crenulate folded micaceous schist with quartz and carbonate streaks.
—36+00 Micaceous quartzose schist with quartz streaks and andalusite crystals.
—35+50 Phyllitic quartzite.
—35+00 Phyllitic quartzite.
Fine grained phyllitic quartzite. A very definite sheeting or bedding joint structure. Foliation: Strike N14°W; Dip 24W.
Fine grained dense phyllitic quartzite.
Foliation Str N16°E Dip 22°W
Considerable quartz and carbonate. Much fracturing and shearing. Foliation dip 20°W
Small quartz veins.
Foliation dip 40W. Phyllitic quartzite. Occurrence of narrow greenish bands possibly containing diopside.
Small fractures and joints contain carbonate.
Shearing parallel to the foliation. Small quartz veins.
Foliation Str. N14°W. Dip 22°W
Small lenses of quartz pegmatite containing sulphide
N84W 90
N56E 80
N48E 85
S86W 85
N74W 90
—35+00 Phyllitic quartzite.
—34+50 Quartzite with quartz streaks and carbonate filled fractures.
—34+00 Quartzite with quartz streaks and carbonate filled fractures.
—33+50 Phyllitic quartzite with quartz vein.
—33+00 Quartzite and phyllitic quartzite with small quartz streaks and lenses.
—32+50 Phyllitic quartzite with carbonate.
—32+00 Phyllitic quartzite with greenish (diopside) band
—31+50 Phyllitic quartzite
—31+00 Phyllitic quartzite with quartz vein.
—30+50 Phyllitic quartzite with quartz vein.
—30+00 Phyllitic quartzite.
LEGEND
BOYLSTON SCHIST
OAKDALE QUARTZITE
Dip Degrees, Approx.
Strike
Bearing Degrees
JOINTS
Tunnel – S78°28'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 30+00 TO 40+00

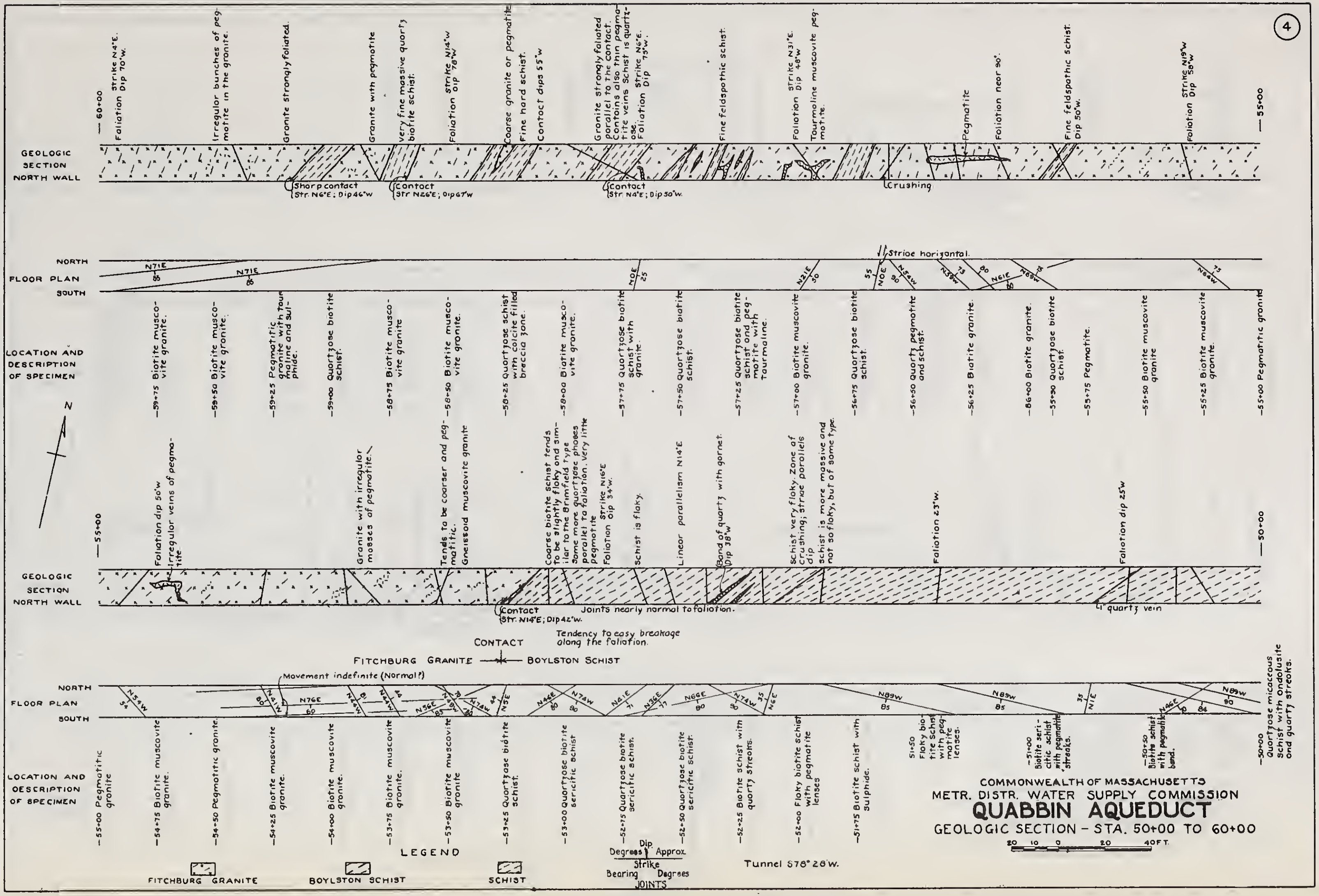


③
GEOLOGIC SECTION NORTH WALL
— 50+00
Foliation dip 27°W.
Quartz lenses and bands more numerous.
Foliation Strike N14°W Dip 28°W
Andalusite crystals ¼" diameter near pegmatite which contains about ½ feldspar.
Foliation dip 27°W.
Foliation and contact dip 28°W. Margin irregular.
2" Schist band
Strike of pegmatite N1°E.
Foliation Strike N9°W. Dip 27°W.
Foliation dip 27°W.
Foliation 20°W
Linear parallelism Str. N9°E Dip 31°W.
12" Crush
Slight crush.
Foliation 27°W.
Foliation Strike N4°W. Dip 43°W.
Possible movement; west side down.
— 45+00
NORTH
FLOOR PLAN
SOUTH
N69W 65
N25E
N65W 90 85
N69W 90
N69W 90
N81W 85
N55E 83
72 N24E
Striae horizontal.
N0E
N69W 85
N64E 87
LOCATION AND DESCRIPTION OF SPECIMEN
–50+00 Quartzose micaceous schist with andalusite and quartz streaks
–49+50 Quartzose sericitic schist.
–49+00 Quartzose sericitic schist.
–48+50 Granite.
–48+00 Quartzose micaceous schist with andalusite.
–47+50 Quartzite with quartz veins.
–47+00 Phyllitic quartzite.
–46+50 Quartzose micaceous schist.
–46+00 Quartzose micaceous sericitic schist.
–45+50 Quartz pegmatite
–45+00 Quartzose micaceous schist with quartz pegmatite.
N
GEOLOGIC SECTION NORTH WALL
—45+00
quartz lenses with feldspar.
Foliation dip 23°W.
Quartzose layers. Small crenulate folds.
Foliation Strike N10°W. Dip 41°W
Linear parallelism N10°W.
Foliation Strike N9W Dip 43°W
Foliation dip 25°W.
Quartz lenses.
Small pegmatitic quartz veins cut across foliation Some contain appreciable white feldspar.
Foliation 13°W.
Small andalusite knots.
Quartzitic and micaceous bands The latter predominating.
Foliation Strike N9°W. Dip 40°W.
6" Crush
Foliation Strike N2°W Dip 16°W
2" Crush.
Foliation Strike N1°E. Dip 32°W.
Quartzose and phyllitic layers. Quartz veins and streaks.
Linear parallelism N4°W.
Foliation dip 15°W. Foliation somewhat crinkled
Much crinkling. Indication of thrust from the west.
6-8" quartz vein obscuring normal fault. Considerable crushing. Quartz contains sulphide.
Gouge west side down
Quartz lenses.
Quartzite band 12" wide, lenses out.
Foliation Strike N12°W. Dip 18°W.
Dip 5°W.
— 40+00
NORTH
FLOOR PLAN
SOUTH
N46E 85
N80W 90
31 N0W
N51E 75
N77E 36
38 N11E
N71E 68
N80W 85
50 14W
N36E 77
N80W 80
LOCATION AND DESCRIPTION OF SPECIMEN
–45+00 Quartzose micaceous schist with quartz pegmatite
–44+50 Quartzose micaceous schist with quartz lenses.
–44+00 Quartzose micaceous schist with andalusite and sulphide.
–43+75 Quartz pegmatite with garnet.
–43+50 Quartzose sericitic schist.
–43+00 Quartzose micaceous sericitic schist with andalusite.
–42+50 Quartzose micaceous sericitic schist.
–42+00 Quartzose micaceous schist with quartz streaks.
–41+50 Quartzose micaceous schist.
41+25 quartz containing quartz filled cavity
–41+00 Micaceous schist with quartz veins
–40+50 Micaceous schist with quartzose layer.
–40+00 Coarsely micaceous schist.
LEGEND
BOYLETON SCHIST
PEGMATITE
Dip Degrees, Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S78°28'W
20 10 0 20 40 FT.

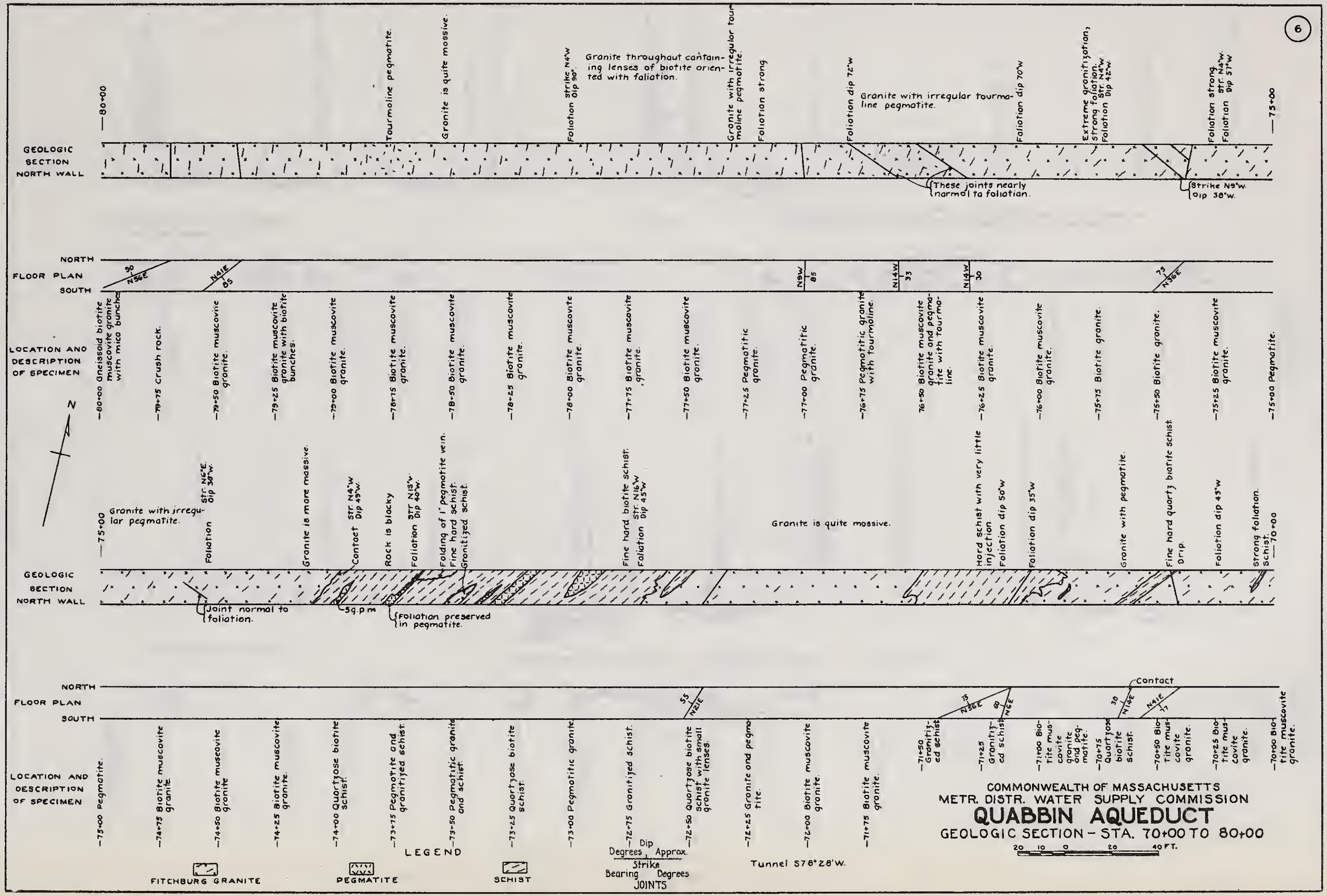
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 40+00 TO 50+00

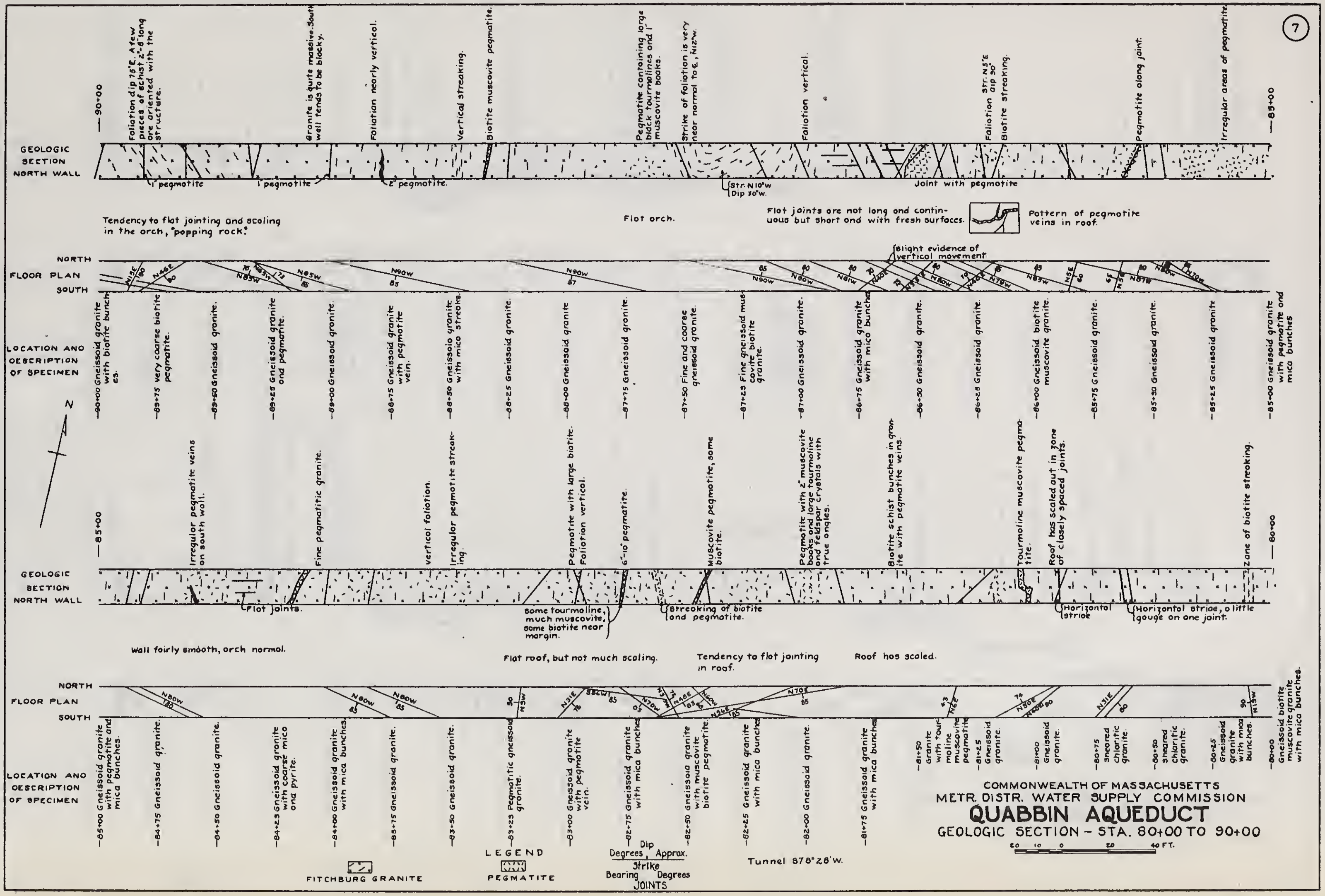

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 50+00 TO 60+00

④
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
60+00
Foliation Strike N4°E. Dip 70°W.
Irregular bunches of pegmatite in the granite.
Granite strongly foliated.
Granite with pegmatite
Very fine massive quartz biotite schist.
Foliation Strike N14°W Dip 78°W
Coarse granite or pegmatite
Fine hard schist.
Contact dips 55°W
Granite strongly foliated parallel to the contact. Contains also thin pegmatite veins Schist is quartzose.
Foliation Strike N6°E. Dip 73°W.
Fine feldspathic schist.
Foliation Strike N31°E. Dip 48°W
Tourmaline muscovite pegmatite.
Pegmatite
Foliation near 90°.
Fine feldspathic schist. Dip 50°W.
Foliation Strike N19°W Dip 58°W
55+00
Sharp contact Str. N6°E; Dip 46°W
Contact Str. N26°E; Dip 67°W
Contact Str. N4°E; Dip 50°W.
Crushing
Striae horizontal.
N71E 85
N71E 85
N0E 25
N21E 30
55 N0E
N54W 90
N39W 73
80 N61E 80
N69W 73
N66W 75
59+75 Biotite muscovite granite.
59+50 Biotite muscovite granite.
59+25 Pegmatitic granite with tourmaline and sulphide.
59+00 Quartzose biotite schist.
58+75 Biotite muscovite granite
58+50 Biotite muscovite granite.
58+25 Quartzose schist with calcite filled breccia zone.
58+00 Biotite muscovite granite.
57+75 Quartzose biotite schist with granite.
57+50 Quartzose biotite schist.
57+25 Quartzose biotite schist and pegmatite with Tourmaline.
57+00 Biotite muscovite granite.
56+75 Quartzose biotite schist.
56+50 Quartz pegmatite and schist.
56+25 Biotite granite.
56+00 Biotite granite.
55+50 Quartzose biotite schist.
55+75 Pegmatite.
55+50 Biotite muscovite granite
55+25 Biotite muscovite granite.
55+00 Pegmatitic granite
55+00
Foliation dip 50°W
Irregular veins of pegmatite
Granite with irregular masses of pegmatite.
Tends to be coarser and pegmatitic.
Gneissoid muscovite granite
Coarse biotite schist tends to be slightly flaky and similar to the Brimfield type Some more quartzose phases parallel to foliation. Very little pegmatite
Foliation Strike N16°E Dip 34°W.
Schist is flaky.
Linear parallelism N14°E
Band of quartz with garnet. Dip 38°W
Schist very flaky. Zone of crushing; striae parallels dip
Schist is more massive and not so flaky, but of same type.
Foliation 23°W.
Foliation dip 25°W
50+00
Contact Str. N14°E; Dip 42°W.
Joints nearly normal to foliation.
Tendency to easy breakage along the foliation.
1' quartz vein
CONTACT
FITCHBURG GRANITE —→←— BOYLSTON SCHIST
Movement indefinite (Normal?)
N54W 54
N41W 80
N76E 60
N24W 81
N24W 64
N56E 85
N38W 80
N74W 64
N5E
N46E 80
N74W 80
N41E 71
N36E 77
N66E 80
N74W 90
35 N6E
N89W 85
N89W 85
35 N1E
N46E 70 84
N89W 90
55+00 Pegmatitic granite
54+75 Biotite muscovite granite.
54+50 Pegmatitic granite.
54+25 Biotite muscovite granite.
54+00 Biotite muscovite granite.
53+75 Biotite muscovite granite.
53+50 Biotite muscovite granite
53+25 Quartzose biotite schist.
53+00 Quartzose biotite sericitic schist
52+75 Quartzose biotite sericitic schist.
52+50 Quartzose biotite sericitic schist.
52+25 Biotite schist with quartz streaks.
52+00 Flaky biotite schist with pegmatite lenses
51+75 Biotite schist with sulphide.
51+50 Flaky biotite schist with pegmatite lenses.
51+00 Biotite sericitic schist with pegmatite streaks.
50+50 Biotite schist with pegmatite band.
50+00 Quartzose micaceous schist with andalusite and quartz streaks.
LEGEND
FITCHBURG GRANITE
BOYLSTON SCHIST
SCHIST
Dip Degrees Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S78°28'W.
20 10 0 20 40 FT.



6
GEOLOGIC SECTION NORTH WALL
—80+00
Tourmoline pegmatite.
Granite is quite massive.
Foliation strike N4°W Dip 90°.
Granite throughout containing lenses of biotite oriented with foliation.
Granite with irregular tourmoline pegmatite.
Foliation strong
Foliation dip 72°W
Granite with irregular tourmoline pegmatite.
Foliation dip 70°W
These joints nearly normal to foliation.
Extreme granitization, strong foliation. Foliation Str. N4°W Dip 42°W.
Foliation strong. Foliation Str. N4°W Dip 57°W
Strike N9°W. Dip 38°W.
—75+00
NORTH
FLOOR PLAN
SOUTH
30
N56E
N41E
85
N9W
85
N14W
33
N14W
30
75
N36E
LOCATION AND DESCRIPTION OF SPECIMEN
—80+00 Gneissoid biotite muscovite granite with mica bunches
—79+75 Crush rock.
—79+50 Biotite muscovite granite.
—79+25 Biotite muscovite granite with biotite bunches.
—79+00 Biotite muscovite granite.
—78+75 Biotite muscovite granite.
—78+50 Biotite muscovite granite.
—78+25 Biotite muscovite granite.
—78+00 Biotite muscovite granite.
—77+75 Biotite muscovite granite.
—77+50 Biotite muscovite granite.
—77+25 Pegmatitic granite.
—77+00 Pegmatitic granite.
—76+75 Pegmatitic granite with tourmaline.
76+50 Biotite muscovite granite and pegmatite with tourmaline.
—76+25 Biotite muscovite granite.
—76+00 Biotite muscovite granite.
—75+75 Biotite granite.
—75+50 Biotite granite.
—75+25 Biotite muscovite granite.
—75+00 Pegmatite.
N
GEOLOGIC SECTION NORTH WALL
—75+00
Granite with irregular pegmatite.
Foliation Str. N6°E. Dip 38°W.
Joint normal to foliation.
Granite is more massive.
Contact Str. N4°W Dip 49°W.
Sq.p.m
Rock is blocky
Foliation Str. N15°W. Dip 40°W.
Foliation preserved in pegmatite.
Folding of 1' pegmatite vein. Fine hard schist. Granitized schist.
Fine hard biotite schist. Foliation Str. N16°W Dip 45°W
Granite is quite massive.
Hard schist with very little injection
Foliation dip 50°W
Foliation dip 35°W
Granite with pegmatite.
Fine hard quartz biotite schist Drip.
Foliation dip 45°W
Strong foliation. Schist.
—70+00
NORTH
FLOOR PLAN
SOUTH
55
N21E
75
N56E
60
N6E
Contact
30
N14E
N41E
77
LOCATION AND DESCRIPTION OF SPECIMEN
—75+00 Pegmatite.
—74+75 Biotite muscovite granite.
—74+50 Biotite muscovite granite
—74+25 Biotite muscovite granite.
—74+00 Quartzose biotite schist.
—73+75 Pegmatite and granitized schist.
—73+50 Pegmatitic granite and schist.
—73+25 Quartzose biotite schist.
—73+00 Pegmatitic granite.
—72+75 Granitized schist.
—72+50 Quartzose biotite schist with small granite lenses.
—72+25 Granite and pegmatite.
—72+00 Biotite muscovite granite.
—71+75 Biotite muscovite granite.
—71+50 Granitized schist
—71+25 Granitized schist
—71+00 Biotite muscovite granite and pegmatite.
—70+75 Quartzose biotite schist.
—70+50 Biotite muscovite granite.
—70+25 Biotite muscovite granite.
—70+00 Biotite muscovite granite.
LEGEND
FITCHBURG GRANITE
PEGMATITE
SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S78°28'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 70+00 TO 80+00

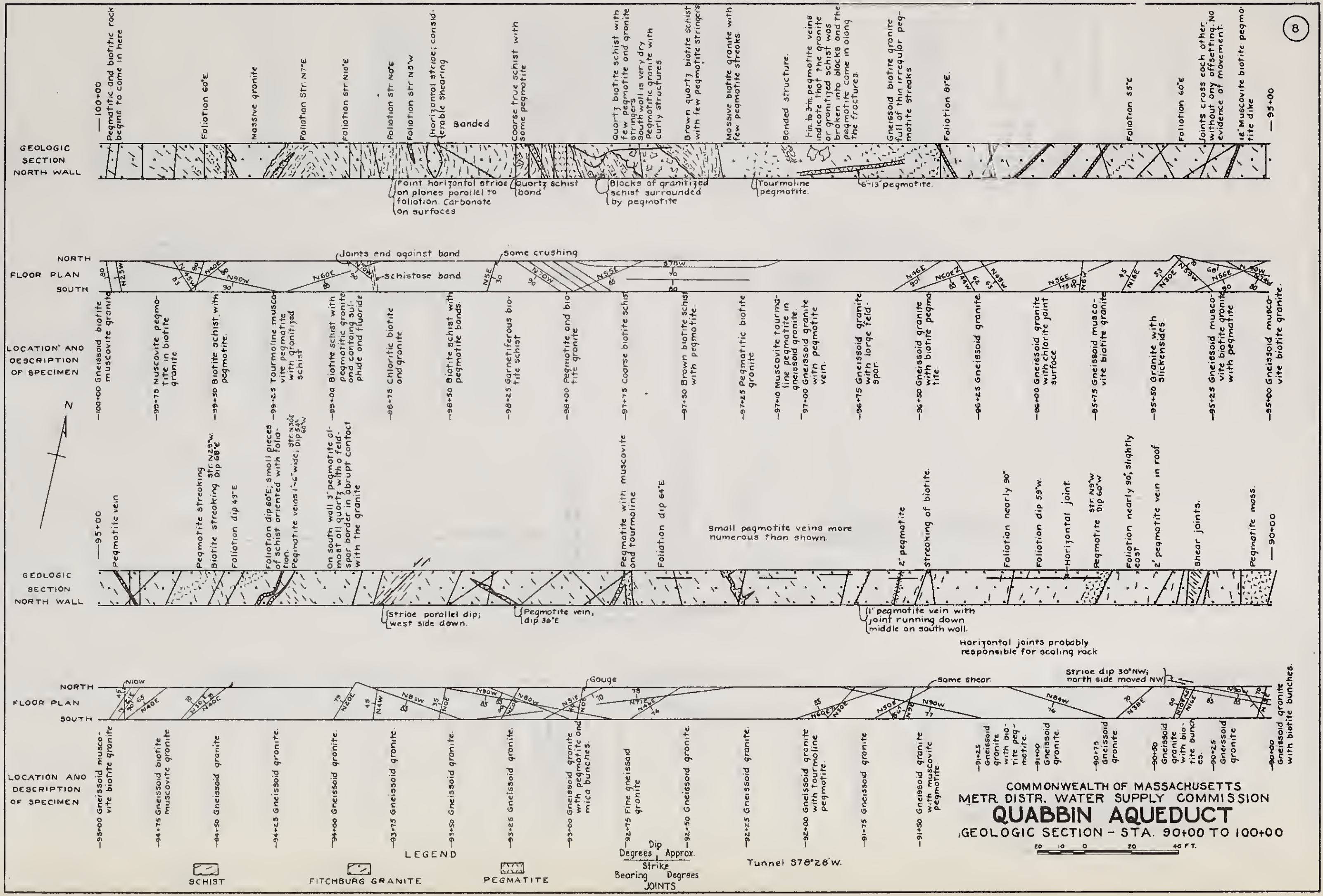


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 80+00 TO 90+00

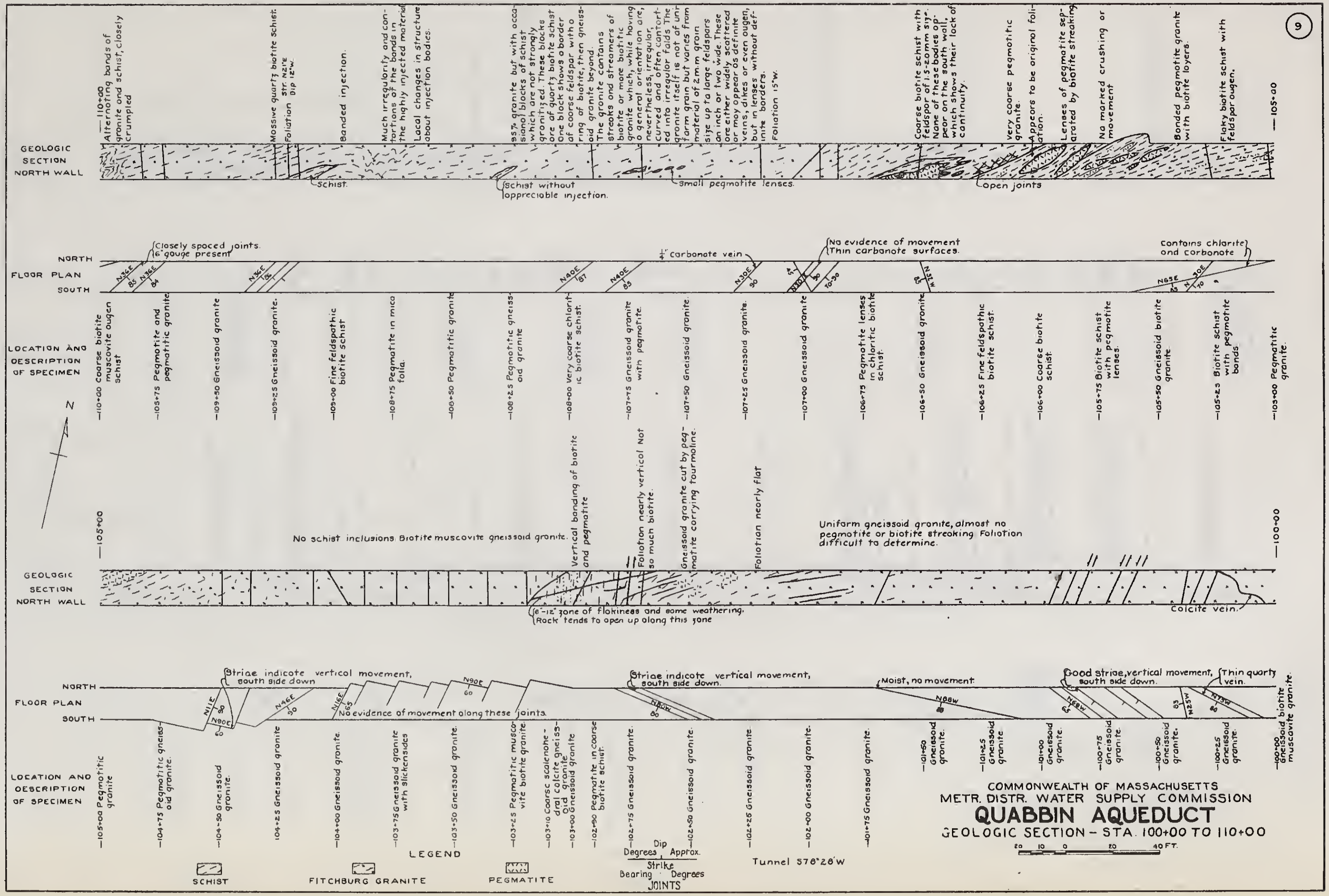
⑦
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
—90+00
Foliation dip 75°E. A few pieces of schist 2"-8" long are oriented with the structure.
1" pegmatite
1" pegmatite
Granite is quite massive. South wall tends to be blocky.
Foliation nearly vertical.
2" pegmatite.
Vertical streaking.
Biotite muscovite pegmatite.
Pegmatite containing large black tourmalines and 1" muscovite books.
Strike of foliation is very near normal to E., N12°W.
Str. N10°W Dip 30°W.
Foliation vertical.
Joint with pegmatite
Foliation Str. N5°E dip 50°
Biotite streaking.
Pegmatite along joint.
Irregular areas of pegmatite.
—85+00
Tendency to flat jointing and scaling in the arch, "popping rock."
Flat arch.
Flat joints are not long and continuous but short and with fresh surfaces.
Pattern of pegmatite veins in roof.
Slight evidence of vertical movement
N15E
N46E
N83W
N85W
N90W
N50W
N60W
N61W
N40E
N80W
N46E
N78W
N83W
N5E
N51E
N80W
N70W
—90+00 Gneissoid granite with biotite bunches.
—89+75 Very coarse biotite pegmatite.
—89+50 Gneissoid granite.
—89+25 Gneissoid granite and pegmatite.
—89+00 Gneissoid granite.
—88+75 Gneissoid granite with pegmatite vein.
—88+50 Gneissoid granite with mica streaks.
—88+25 Gneissoid granite.
—88+00 Gneissoid granite
—87+75 Gneissoid granite.
—87+50 Fine and coarse gneissoid granite.
—87+25 Fine gneissoid muscovite biotite granite.
—87+00 Gneissoid granite.
—86+75 Gneissoid granite with mica bunches
—86+50 Gneissoid granite.
—86+25 Gneissoid granite.
—86+00 Gneissoid biotite muscovite granite.
—85+75 Gneissoid granite.
—85+50 Gneissoid granite.
—85+25 Gneissoid granite.
—85+00 Gneissoid granite with pegmatite and mica bunches
—85+00
Irregular pegmatite veins on south wall.
Flat joints.
Fine pegmatitic granite.
Vertical foliation.
Irregular pegmatite streaking.
Pegmatite with large biotite.
Foliation vertical.
Some tourmaline, much muscovite, some biotite near margin.
6"-10" pegmatite.
Muscovite pegmatite, some biotite.
Streaking of biotite and pegmatite.
Pegmatite with 2" muscovite books and large tourmaline and feldspar crystals with true angles.
Biotite schist bunches in granite with pegmatite veins.
Tourmaline muscovite pegmatite.
Roof has scaled out in zone of closely spaced joints.
Horizontal striae
Horizontal striae, a little gouge on one joint.
Zone of biotite streaking.
—80+00
Wall fairly smooth, arch normal.
Flat roof, but not much scaling.
Tendency to flat jointing in roof.
Roof has scaled.
N80W
N3W
N31E
S86W
N70W
N46E
N56E
N70E
N6E
N30E
N60E
N31E
N15W
—85+00 Gneissoid granite with pegmatite and mica bunches.
—84+75 Gneissoid granite.
—84+50 Gneissoid granite.
—84+25 Gneissoid granite with coarse mica and pyrite.
—84+00 Gneissoid granite with mica bunches
—83+75 Gneissoid granite.
—83+50 Gneissoid granite.
—83+25 Pegmatitic gneissoid granite.
—83+00 Gneissoid granite with pegmatite vein.
—82+75 Gneissoid granite with mica bunches
—82+50 Gneissoid granite with muscovite biotite pegmatite
—82+25 Gneissoid granite with mica bunches
—82+00 Gneissoid granite.
—81+75 Gneissoid granite with mica bunches
—81+50 Granite with tourmaline muscovite pegmatite
—81+25 Gneissoid granite.
—81+00 Gneissoid granite.
—80+75 Sheared chloritic granite.
—80+50 Sheared chloritic granite.
—80+25 Gneissoid granite with mica bunches.
—80+00 Gneissoid biotite muscovite granite with mica bunches.
LEGEND
FITCHBURG GRANITE
PEGMATITE
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel S78°28'W.
20 10 0 20 40 FT.


8
GEOLOGIC SECTION NORTH WALL
100+00
Pegmatitic and biotitic rock begins to come in here
Foliation 60°E.
Massive granite
Foliation Str. N7°E.
Foliation Str N10°E
Foliation Str N0°E
Foliation Str N5°W
Horizontal striae; considerable shearing
Banded
Coarse true schist with some pegmatite
Quartz biotite schist with few pegmatite and granite stringers
South wall is very dry
Pegmatitic granite with curly structures
Brown quartz biotite schist with few pegmatite stringers
Massive biotite granite with few pegmatite streaks.
Banded structure.
1 in. to 3 in. pegmatite veins indicate that the granite or granitized schist was broken into blocks and the pegmatite came in along the fractures.
Gneissoid biotite granite full of thin irregular pegmatite streaks
Foliation 81°E.
Foliation 55°E
Foliation 60°E
Joints cross each other without any offsetting. No evidence of movement.
12" Muscovite biotite pegmatite dike
95+00
Faint horizontal striae on planes parallel to foliation. Carbonate on surfaces
Quartz schist band
Blocks of granitized schist surrounded by pegmatite
Tourmaline pegmatite.
6"-13" pegmatite.
NORTH
FLOOR PLAN
SOUTH
Joints end against band
Some crushing
Schistose band
N23W
80
N45W
83
90
N40E
N90W
N60E
N70W
N5E
30
N55E
85
S78W
70
80
N46E
N60E
N44W
N49W
63
N56E
75
50
N6W
45
N16E
53
N30E
N59W
68
N90W
N74W
LOCATION AND DESCRIPTION OF SPECIMEN
100+00 Gneissoid biotite muscovite granite
99+75 Muscovite pegmatite in biotite granite
99+50 Biotite schist with pegmatite.
99+25 Tourmaline muscovite pegmatite with granitized schist
99+00 Biotite schist with pegmatitic granite and containing sulphide and fluoride
98+75 Chloritic biotite and granite
98+50 Biotite schist with pegmatite bands.
98+25 Garnetiferous biotite schist
98+00 Pegmatite and biotite granite
97+75 Coarse biotite schist
97+50 Brown biotite schist with pegmatite
97+25 Pegmatitic biotite granite
97+10 Muscovite tourmaline pegmatite in gneissoid granite.
97+00 Gneissoid granite with pegmatite vein.
96+75 Gneissoid granite with large feldspar
96+50 Gneissoid granite with biotite pegmatite.
96+25 Gneissoid granite.
96+00 Gneissoid granite with chlorite joint surface.
95+75 Gneissoid muscovite biotite granite
95+50 Granite with slickensides
95+25 Gneissoid muscovite biotite granite with pegmatite
95+00 Gneissoid muscovite biotite granite.
N
GEOLOGIC SECTION NORTH WALL
95+00
Pegmatite vein
Pegmatite streaking
Biotite streaking Str. N29°W. Dip 68°E
Foliation dip 43°E
Foliation dip 60°E; small pieces of schist oriented with foliation.
Pegmatite veins 1"-6" wide; Str. N30E Dip 54° 60W
On south wall 3' pegmatite almost all quartz with a feldspar border in abrupt contact with the granite
Pegmatite with muscovite and tourmaline
Foliation dip 64°E
Small pegmatite veins more numerous than shown.
2" pegmatite
Streaking of biotite.
Foliation nearly 90°
Foliation dip 59°W.
Horizontal joint.
Pegmatite Str. N9°W Dip 60°W
Foliation nearly 90°, slightly east
2' pegmatite vein in roof.
Shear joints.
Pegmatite mass.
90+00
Striae parallel dip; west side down.
Pegmatite vein, dip 30°E
1" pegmatite vein with joint running down middle on south wall.
Horizontal joints probably responsible for scaling rock
NORTH
FLOOR PLAN
SOUTH
N10W
Gouge
Some shear.
Striae dip 30°NW; north side moved NW
45
N21E
90
65
N40E
70
N30E
N40E
79
N20E
45
N4W
N85W
85
35
N0E
N90W
N80W
N51E
N0E
78
N71E
N46E
74
85
N60E
N30E
N50E
N3E
N90W
77
N84W
76
70
N38E
80
N10E
N16E
83
85
N90W
70
N13E
LOCATION AND DESCRIPTION OF SPECIMEN
95+00 Gneissoid muscovite biotite granite
94+75 Gneissoid biotite muscovite granite
94+50 Gneissoid granite
94+25 Gneissoid granite.
94+00 Gneissoid granite.
93+75 Gneissoid granite.
93+50 Gneissoid granite.
93+25 Gneissoid granite.
93+00 Gneissoid granite with pegmatite and mica bunches.
92+75 Fine gneissoid granite
92+50 Gneissoid granite.
92+25 Gneissoid granite.
92+00 Gneissoid granite with tourmaline pegmatite.
91+75 Gneissoid granite
91+50 Gneissoid granite with muscovite pegmatite
91+25 Gneissoid granite with biotite pegmatite.
91+00 Gneissoid granite.
90+75 Gneissoid granite.
90+50 Gneissoid granite with biotite bunches.
90+25 Gneissoid granite
90+00 Gneissoid granite with biotite bunches.
LEGEND
SCHIST
FITCHBURG GRANITE
PEGMATITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S78°28'W.
20 10 0 20 40 FT.

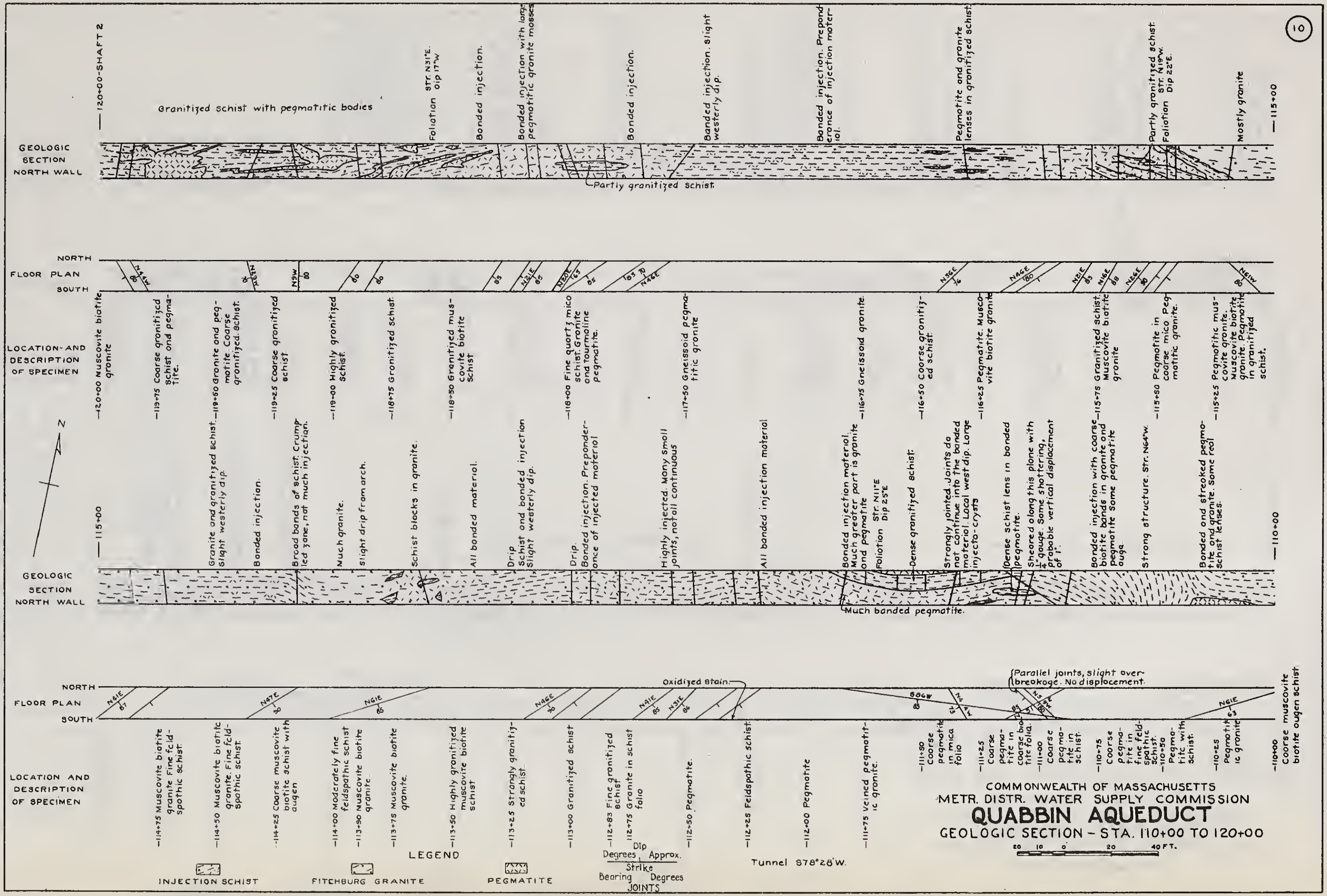
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION - STA. 90+00 TO 100+00


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 100+00 TO 110+00

9
GEOLOGIC SECTION NORTH WALL
110+00
Alternating bands of granite and schist, closely crumpled
Massive quartz biotite schist.
Foliation Str. N21°E Dip 12°W.
Banded injection.
Much irregularity and contortions of the bands in the highly injected material
Local changes in structure about injection bodies.
95% granite but with occasional blocks of schist which are not strongly granitized. These blocks are of quartz biotite schist. One block shows a border of coarse feldspar with a ring of biotite, then gneissoid granite beyond.
The granite contains streaks and streamers of biotite or more biotitic granite which, while having a general orientation are, nevertheless, irregular, curved and often contorted into irregular folds. The granite itself is not of uniform grain but varies from material of 2 m.m grain size up to large feldspars an inch or two wide. These are either widely scattered or may appear as definite veins, dikes or even augen, but in lenses without definite borders.
Foliation 15°W.
Coarse biotite schist with feldspar of 1.5-2.0mm size. None of these bodies appear on the south wall, which shows their lack of continuity.
Very coarse pegmatitic granite.
Appears to be original foliation.
Lenses of pegmatite separated by biotite streaking.
No marked crushing or movement
Banded pegmatite granite with biotite layers.
Flaky biotite schist with feldspar augen.
105+00
Schist.
Schist without appreciable injection.
Small pegmatite lenses.
Open joints
FLOOR PLAN
NORTH
SOUTH
Closely spaced joints. 6" gouge present
N36E 85
N36E 84
N36E 86
N40E 87
N40E 85
¼" carbonate vein
N30E 90
45
N30E
90
10-90
No evidence of movement Thin carbonate surfaces.
N32W 85
Contains chlorite and carbonate
N65E 85
N30E 70
LOCATION AND DESCRIPTION OF SPECIMEN
110+00 Coarse biotite muscovite augen schist
109+75 Pegmatite and pegmatitic granite.
109+50 Gneissoid granite
109+25 Gneissoid granite.
109+00 Fine feldspathic biotite schist
108+75 Pegmatite in mica folia.
108+50 Pegmatitic granite
108+25 Pegmatitic gneissoid granite
108+00 Very coarse chloritic biotite schist.
107+75 Gneissoid granite with pegmatite.
107+50 Gneissoid granite.
107+25 Gneissoid granite.
107+00 Gneissoid granite
106+75 Pegmatite lenses in chloritic biotite schist.
106+50 Gneissoid granite
106+25 Fine feldspathic biotite schist.
106+00 Coarse biotite schist.
105+75 Biotite schist with pegmatite lenses.
105+50 Gneissoid biotite granite.
105+25 Biotite schist with pegmatite bands
105+00 Pegmatitic granite.
N
GEOLOGIC SECTION NORTH WALL
105+00
No schist inclusions. Biotite muscovite gneissoid granite.
Vertical banding of biotite and pegmatite
Foliation nearly vertical Not so much biotite.
Gneissoid granite cut by pegmatite carrying tourmaline.
Foliation nearly flat
Uniform gneissoid granite, almost no pegmatite or biotite streaking. Foliation difficult to determine.
100+00
6"-12" zone of flakiness and some weathering. Rock tends to open up along this zone
Calcite vein.
FLOOR PLAN
NORTH
SOUTH
Striae indicate vertical movement, south side down
N11E 90
N90E 60
N46E 90
N16E 65
N90E 60
No evidence of movement along these joints.
Striae indicate vertical movement, south side down.
N80W 80
Moist, no movement.
N88W 80
Good striae, vertical movement, south side down.
N68W 65
83 N25W
N73W 80
Thin quartz vein.
LOCATION AND DESCRIPTION OF SPECIMEN
105+00 Pegmatitic granite
104+75 Pegmatitic gneissoid granite.
104+50 Gneissoid granite.
104+25 Gneissoid granite
104+00 Gneissoid granite.
103+75 Gneissoid granite with slickensides
103+50 Gneissoid granite.
103+25 Pegmatitic muscovite biotite granite.
103+10 Coarse scalenohedral calcite gneissoid granite
103+00 Gneissoid granite
102+90 Pegmatite in coarse biotite schist.
102+75 Gneissoid granite.
102+50 Gneissoid granite.
102+25 Gneissoid granite
102+00 Gneissoid granite.
101+75 Gneissoid granite.
101+50 Gneissoid granite.
101+25 Gneissoid granite
101+00 Gneissoid granite.
100+75 Gneissoid granite.
100+50 Gneissoid granite.
100+25 Gneissoid granite.
100+00 Gneissoid biotite muscovite granite.
LEGEND
SCHIST
FITCHBURG GRANITE
PEGMATITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S78°28'W
20 10 0 20 40 FT.

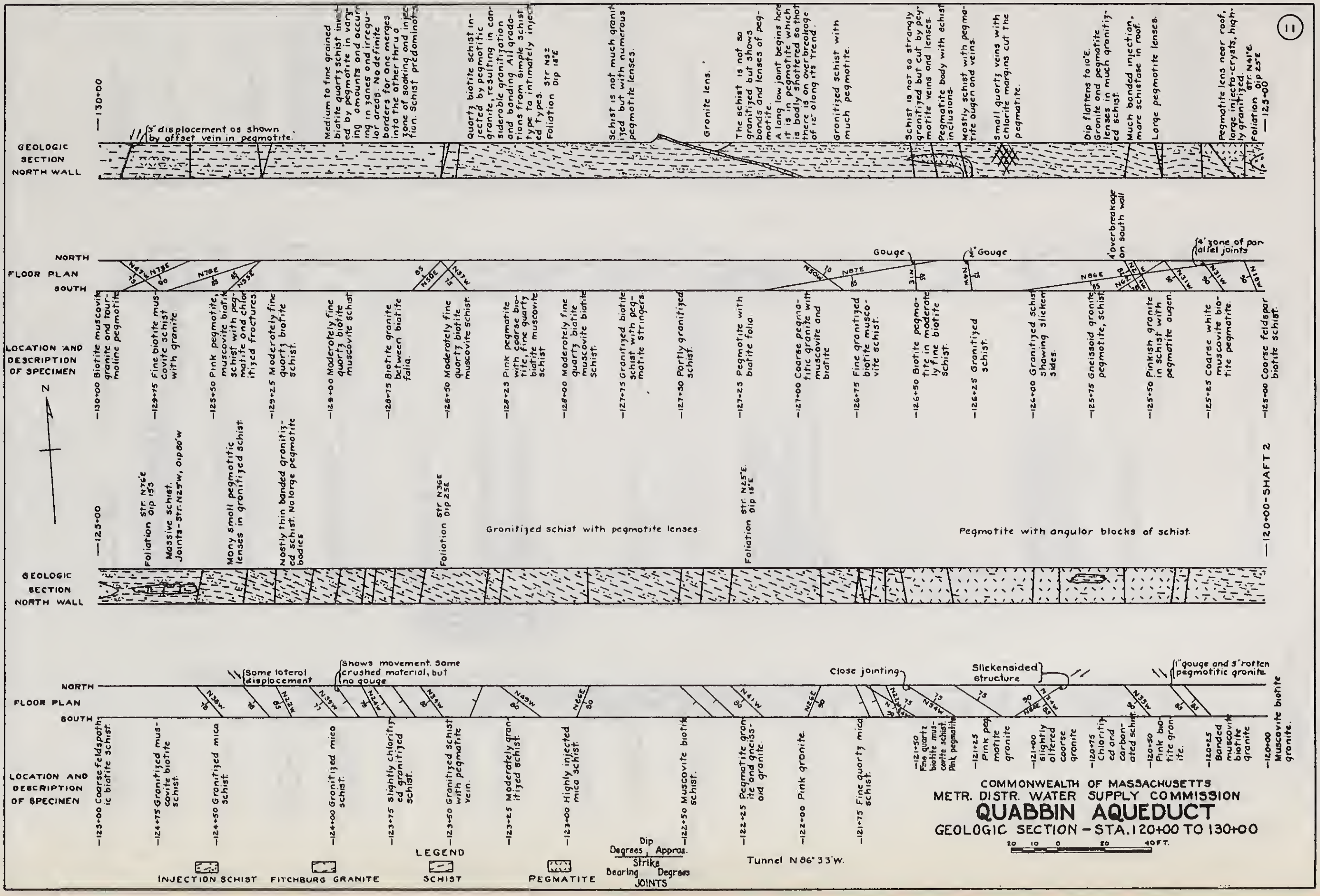


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

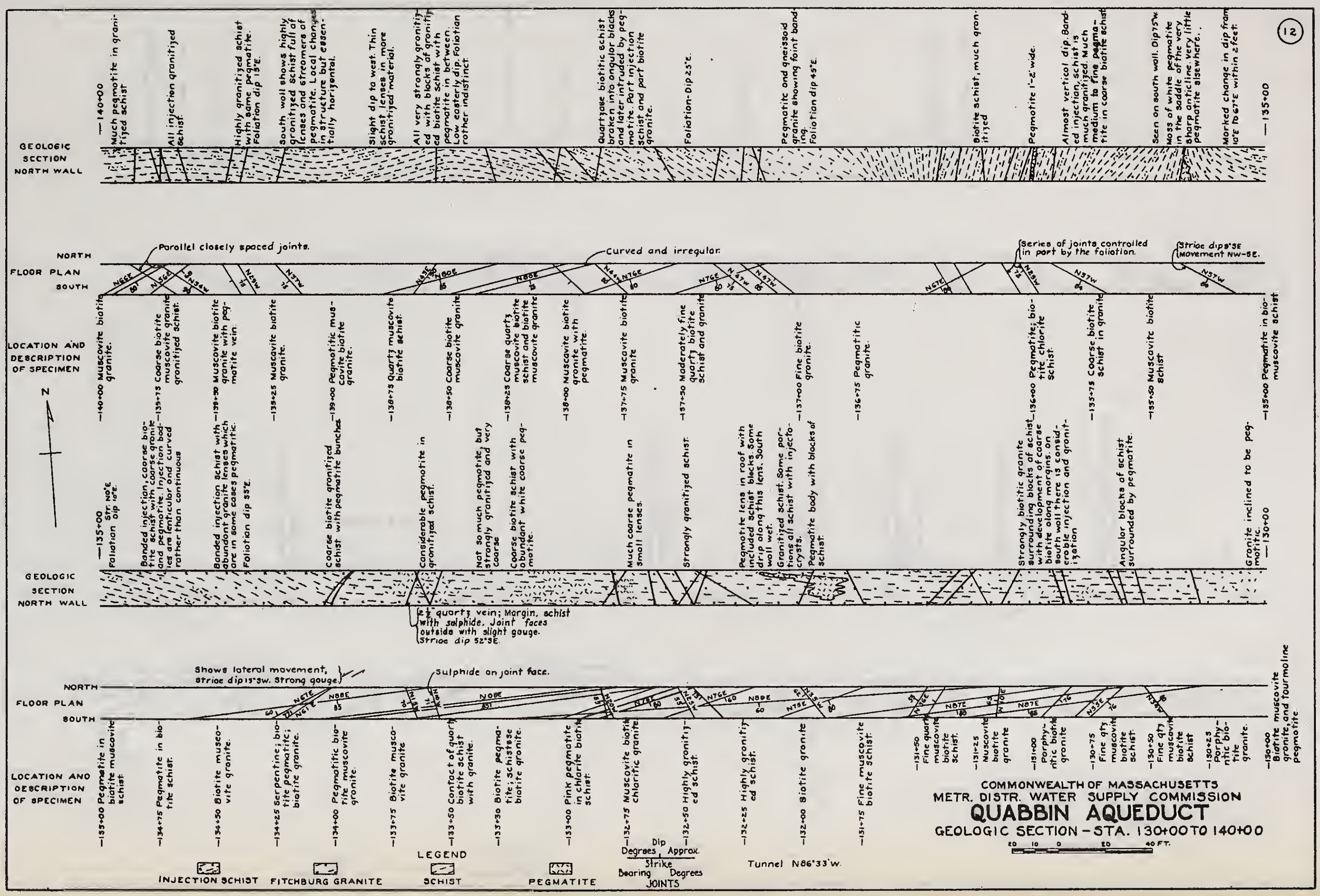
QUABBIN AQUEDUCT

GEOLOGIC SECTION - STA. 110+00 TO 120+00

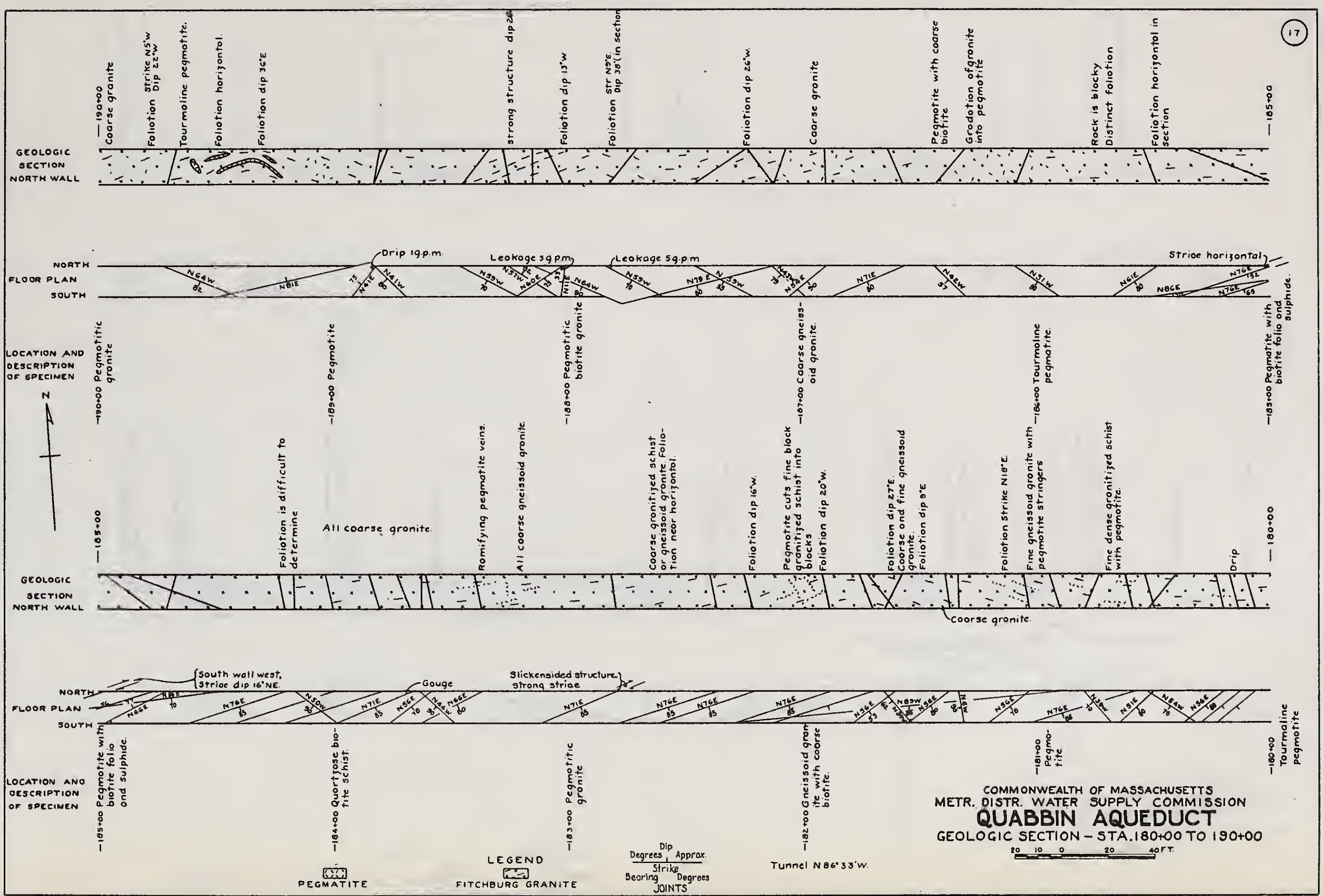
10
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
120+00-SHAFT 2
Granitized schist with pegmatitic bodies
Foliation Str. N31°E. Dip 17°W
Bonded injection.
Bonded injection with large pegmatitic granite masses
Bonded injection.
Banded injection. Slight westerly dip.
Bonded injection. Preponderance of injection material.
Pegmatite and granite lenses in granitized schist.
Partly granitized schist. Str. N19°W. Foliation Dip 22°E.
Mostly granite
115+00
Partly granitized schist.
120+00 Muscovite biotite granite
119+75 Coarse granitized schist and pegmatite.
119+50 Granite and pegmatite. Coarse granitized schist.
119+25 Coarse granitized schist
119+00 Highly granitized schist.
118+75 Granitized schist.
118+50 Granitized muscovite biotite schist
118+00 Fine quartz mica schist. Granite and tourmaline pegmatite.
117+50 Gneissoid pegmatitic granite
116+75 Gneissoid granite.
116+50 Coarse granitized schist.
116+25 Pegmatite. Muscovite biotite granite
115+75 Granitized schist. Muscovite biotite granite
115+50 Pegmatite in coarse mica pegmatitic granite.
115+25 Pegmatitic muscovite granite. Muscovite biotite granite. Pegmatite in granitized schist.
115+00
Granite and granitized schist. Slight westerly dip.
Bonded injection.
Broad bands of schist. Crumpled zone, not much injection.
Much granite.
Slight drip from arch.
Schist blocks in granite.
All bonded material.
Drip Schist and bonded injection Slight westerly dip.
Drip. Bonded injection. Preponderance of injected material
Highly injected. Many small joints, not all continuous
All banded injection material
Bonded injection material. Much greater part is granite and pegmatite Foliation Str. N11°E Dip 25°E
Dense granitized schist.
Strongly jointed. Joints do not continue into the banded material. Local west dip. Large injecto-crysts
Dense schist lens in bonded pegmatite.
Sheared along this plane with 1/4" gouge. Some shattering, probable vertical displacement of 1'.
Bonded injection with coarse biotite bands in granite and pegmatite Some pegmatite auga
Strong structure. Str. N64°W.
Bonded and streaked pegmatite and granite. Some real schist lenses.
110+00
Much banded pegmatite.
Parallel joints, slight overbreakage. No displacement.
Oxidized stain
114+75 Muscovite biotite granite Fine feldspathic schist.
114+50 Muscovite biotite granite. Fine feldspathic schist.
114+25 Coarse muscovite biotite schist with augen
114+00 Moderately fine feldspathic schist
113+90 Muscovite biotite granite.
113+75 Muscovite biotite granite.
113+50 Highly granitized muscovite biotite schist
113+25 Strongly granitized schist.
113+00 Granitized schist
112+83 Fine granitized schist
112+75 Granite in schist folia
112+50 Pegmatite.
112+25 Feldspathic schist.
112+00 Pegmatite
111+75 Veined pegmatitic granite.
111+50 Coarse pegmatite in mica folia
111+25 Coarse pegmatite in coarse biotite folia.
111+00 Coarse pegmatite in schist.
110+75 Coarse pegmatite in fine feldspathic schist.
110+50 Pegmatite with schist.
110+25 Pegmatitic granite
110+00 Coarse muscovite biotite augen schist
LEGEND
INJECTION SCHIST
FITCHBURG GRANITE
PEGMATITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S78°28'W.
20 10 0 20 40 FT.
N


11
GEOLOGIC SECTION NORTH WALL
— 130+00
3" displacement as shown by offset vein in pegmatite.
Medium to fine grained biotite quartz schist invaded by pegmatite in varying amounts and occurring in zones and irregular areas. No definite borders for one merges into the other thru a zone of soaking and injection. Schist predominates.
Quartz biotite schist injected by pegmatitic granite, resulting in considerable granitization and banding. All gradations from simple schist type to intimately injected types.
Foliation Str N5± Dip 18°E
Schist is not much granitized but with numerous pegmatite lenses.
Granite lens.
The schist is not so granitized but shows bands and lenses of pegmatite.
A long low joint begins here it is in pegmatite which is bodily shattered so that there is an overbreakage of 12" along its trend.
Granitized schist with much pegmatite.
Schist is not so strongly granitized but cut by pegmatite veins and lenses.
Pegmatite body with schist inclusions.
Mostly schist with pegmatite augen and veins.
Small quartz veins with chlorite margins cut the pegmatite.
Dip flattens to 10°E.
Granite and pegmatite lenses in much granitized schist.
Much banded injection, more schistose in roof.
Large pegmatite lenses.
Pegmatite lens near roof, large injecto-crysts, highly granitized.
Foliation Str. N41°E Dip 25°E
— 125+00
NORTH
FLOOR PLAN
SOUTH
N47E
N78E
N78E
N35E
N50E
N37E
N50W
N87E
Gouge
31N
½" Gouge
N4W
N86E
N62
N2E
4' overbreakage on south wall
4' zone of parallel joints
N31W
N31W
N18W
LOCATION AND DESCRIPTION OF SPECIMEN
—130+00 Biotite muscovite granite and tourmaline pegmatite
—129+75 Fine biotite muscovite schist with granite
—125+50 Pink pegmatite, muscovite biotite schist with pegmatite and chloritized fractures.
—129+25 Moderately fine quartz biotite schist.
—129+00 Moderately fine quartz biotite muscovite schist
—128+75 Biotite granite between biotite folia.
—128+50 Moderately fine quartz biotite muscovite schist.
—128+25 Pink pegmatite with coarse biotite, fine quartz biotite muscovite schist
—128+00 Moderately fine quartz biotite muscovite biotite schist.
—127+75 Granitized biotite schist with pegmatite stringers.
—127+50 Partly granitized schist.
—127+25 Pegmatite with biotite folia
—127+00 Coarse pegmatitic granite with muscovite and biotite
—126+75 Fine granitized biotite muscovite schist.
—126+50 Biotite pegmatite in moderately fine biotite schist.
—126+25 Granitized schist.
—126+00 Granitized schist showing slickensides.
—125+75 Gneissoid granite, pegmatite, schist.
—125+50 Pinkish granite in schist with pegmatite augen.
—125+25 Coarse white muscovite biotite pegmatite.
—125+00 Coarse feldspar biotite schist.
N
GEOLOGIC SECTION NORTH WALL
—125+00
Foliation Str. N76E Dip 15S
Massive schist. Joints-Str. N25W, Dip 80°W
Many small pegmatitic lenses in granitized schist.
Mostly thin banded granitized schist. No large pegmatite bodies
Foliation Str N36E Dip 25E
Granitized schist with pegmatite lenses.
Foliation Str. N25°E. Dip 15°E
Pegmatite with angular blocks of schist.
—120+00-SHAFT 2
NORTH
FLOOR PLAN
SOUTH
Some lateral displacement
Shows movement. Some crushed material, but no gouge
N38W
N22W
N39W
N24W
N34W
N49W
N66E
N41W
N26E
Close jointing
N22W
N54W
Slickensided structure
N
N34W
N66E
N35W
1" gouge and 5" rotten pegmatitic granite
LOCATION AND DESCRIPTION OF SPECIMEN
—123+00 Coarse feldspathic biotite schist.
—124+75 Granitized muscovite biotite schist.
—124+50 Granitized mica schist.
—124+00 Granitized mica schist.
—123+75 Slightly chloritized granitized schist.
—123+50 Granitized schist with pegmatite vein.
—123+25 Moderately granitized schist.
—123+00 Highly injected mica schist.
—122+50 Muscovite biotite schist.
—122+25 Pegmatite granite and gneissoid granite.
—122+00 Pink granite.
—121+75 Fine quartz mica schist.
—121+50 Fine quartz biotite muscovite schist. Pink pegmatite
—121+25 Pink pegmatite granite
—121+00 Slightly altered coarse granite
—120+75 Chloritized and carbonated schist.
—120+50 Pink biotite granite.
—120+25 Banded muscovite biotite granite
—120+00 Muscovite biotite granite.
LEGEND
INJECTION SCHIST
FITCHBURG GRANITE
SCHIST
PEGMATITE
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86° 33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 120+00 TO 130+00


⑫
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
— 140+00
Much pegmatite in granitized schist
All injection granitized schist.
Highly granitized schist with some pegmatite. Foliation dip 15°E.
South wall shows highly granitized schist full of lenses and streamers of pegmatite. Local changes in structure but essentially horizontal.
Slight dip to west. Thin schist lenses in more granitized material.
All very strongly granitized with blocks of granitized biotite schist with pegmatite in between. Low easterly dip. Foliation rather indistinct.
Quartzose biotitic schist broken into angular blocks and later intruded by pegmatite. Part injection schist and part biotite granite.
Foliation-Dip 25°E.
Pegmatite and gneissoid granite showing faint banding. Foliation dip 45°E.
Biotite schist, much granitized
Pegmatite 1'-2' wide.
Almost vertical dip. Banded injection, schist is much granitized. Much medium to fine pegmatite in coarse biotite schist
Seen on south wall. Dip 75°W.
Mass of white pegmatite in the saddle of the very sharp anticline. Very little pegmatite elsewhere.
Marked change in dip from 10°E to 67°E within 2 feet.
— 135+00
Parallel closely spaced joints.
Curved and irregular.
Series of joints controlled in part by the foliation.
Striae dip 5°SE Movement NW-SE.
N66E
N56E
N34W
N27W
N37W
N43E
N80E
N80E
N44½W
N76E
N76E
N47W
N47W
N67E
N25W
N37W
N37W
—140+00 Muscovite biotite granite.
—139+75 Coarse biotite muscovite granite granitized schist.
—139+50 Muscovite biotite granite with pegmatite vein.
—139+25 Muscovite biotite granite.
—139+00 Pegmatitic muscovite biotite granite.
—138+75 Quartz muscovite biotite schist.
—138+50 Coarse biotite muscovite granite
—138+25 Coarse quartz muscovite biotite schist and biotite muscovite granite
—138+00 Muscovite biotite granite with pegmatite.
—137+75 Muscovite biotite granite
—137+50 Moderately fine quartz biotite schist and granite
—137+00 Fine biotite granite.
—136+75 Pegmatitic granite.
—136+00 Pegmatite; biotite chlorite schist.
—135+75 Coarse biotite schist in granite
—135+50 Muscovite biotite schist
—135+00 Pegmatite in biomuscovite schist
—135+00
Foliation Str. N0°E Dip 10°E.
Banded injection, coarse biotite schist with coarse granite and pegmatite. Injection bodies are lenticular and curved rather than continuous
Banded injection schist with abundant granite lenses which are in some cases pegmatitic. Foliation dip 55°E.
Coarse biotite granitized schist with pegmatite bunches
Considerable pegmatite in granitized schist.
Not so much pegmatite, but strongly granitized and very coarse
Coarse biotite schist with abundant white coarse pegmatite.
Much coarse pegmatite in small lenses.
Strongly granitized schist.
Pegmatite lens in roof with included schist blocks. Some drip along this lens. South wall wet.
Granitized schist. Some portions all schist with injecto-crysts.
Pegmatite body with blocks of schist.
Strongly biotitic granite surrounding blocks of schist with development of coarse biotite along margins. On south wall there is considerable injection and granitization
Angular blocks of schist surrounded by pegmatite.
Granite inclined to be pegmatitic.
— 130+00
2½" quartz vein; Margin, schist with sulphide. Joint faces outside with slight gouge. Striae dip 52°SE.
Shows lateral movement, striae dip 15°SW. Strong gouge.
Sulphide on joint face.
N67E
N61E
N88E
N08E
N76E
N25W
N76E
N80E
N75E
N35W
N76E
N87E
N10E
N87E
N35E
N34W
—135+00 Pegmatite in biotite muscovite schist
—134+75 Pegmatite in biotite schist.
—134+50 Biotite muscovite granite.
—134+25 Serpentine; biotite pegmatite; biotite granite.
—134+00 Pegmatitic biotite muscovite granite.
—133+75 Biotite muscovite granite
—133+50 Contact of quartz biotite schist with granite.
—133+30 Biotite pegmatite; schistose biotite granite.
—133+00 Pink pegmatite in chlorite biotite schist.
—132+75 Muscovite biotite chloritic granite.
—132+50 Highly granitized schist.
—132+25 Highly granitized schist.
—132+00 Biotite granite
—131+75 Fine muscovite biotite schist.
—131+50 Fine quartz muscovite biotite schist.
—131+25 Muscovite biotite granite
—131+00 Porphyritic biotite granite
—130+75 Fine qtz muscovite biotite schist.
—130+50 Fine qtz muscovite biotite schist
—130+25 Porphyritic biotite granite.
—130+00 Biotite muscovite granite, and tourmoline pegmatite
LEGEND
INJECTION SCHIST
FITCHBURG GRANITE
SCHIST
PEGMATITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 130+00 TO 140+00


17
GEOLOGIC SECTION NORTH WALL
190+00 Coarse granite
Foliation Strike N5°W Dip 22°W
Tourmaline pegmatite.
Foliation horizontal.
Foliation dip 36°E
strong structure dip 28°
Foliation dip 13°W
Foliation Str N9°E. Dip 38°(in section
Foliation dip 26°W.
Coarse granite
Pegmatite with coarse biotite
Gradation of granite into pegmatite
Rock is blocky
Distinct foliation
Foliation horizontal in section
185+00
NORTH
FLOOR PLAN
SOUTH
Drip 19 g.p.m.
Leakage 3 g.p.m.
Leakage 5 g.p.m.
Striae horizontal
N64W 82
N81E
N41E 75
N41W 80
N59W 70
N37W
N60E
N11E 75
N64W 80
N59W 70
N78E 80
N39W 85
N43W
N54E 90
N71E 80
N42W 57
N31W 80
N61E 80
N86E
N76E 152
N76E 69
LOCATION AND DESCRIPTION OF SPECIMEN
190+00 Pegmatitic granite
189+00 Pegmatite
188+00 Pegmatitic biotite granite
187+00 Coarse gneissoid granite.
186+00 Tourmaline pegmatite.
185+00 Pegmatite with biotite folia and sulphide.
N
GEOLOGIC SECTION NORTH WALL
185+00
Foliation is difficult to determine
All coarse granite.
Ramifying pegmatite veins.
All coarse gneissoid granite.
Coarse granitized schist or gneissoid granite. Foliation near horizontal.
Foliation dip 16°W.
Pegmatite cuts fine block granitized schist into blocks
Foliation dip 20°W.
Foliation dip 27°E.
Coarse and fine gneissoid granite.
Foliation dip 9°E
Foliation Strike N18°E.
Fine gneissoid granite with pegmatite stringers
Fine dense granitized schist with pegmatite.
Drip
180+00
Coarse granite.
NORTH
FLOOR PLAN
SOUTH
South wall west, Striae dip 16°NE.
Gouge
Slickensided structure, strong striae
N66E
N81E 70
N76E 85
N50W 90
N71E 85
N56E 70
N44W 90
N66E 80
N71E 85
N76E 85
N76E 85
N76E 85
N36E 53
N83W
N56E 80
N56E 70
N76E 88
N38W 70
N31E 80
N64W 70
N56E
LOCATION AND DESCRIPTION OF SPECIMEN
185+00 Pegmatite with biotite folia and sulphide.
184+00 Quartzose biotite schist.
183+00 Pegmatitic granite
182+00 Gneissoid granite with coarse biotite.
181+00 Pegmatite
180+00 Tourmaline pegmatite
Tunnel N 86°33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

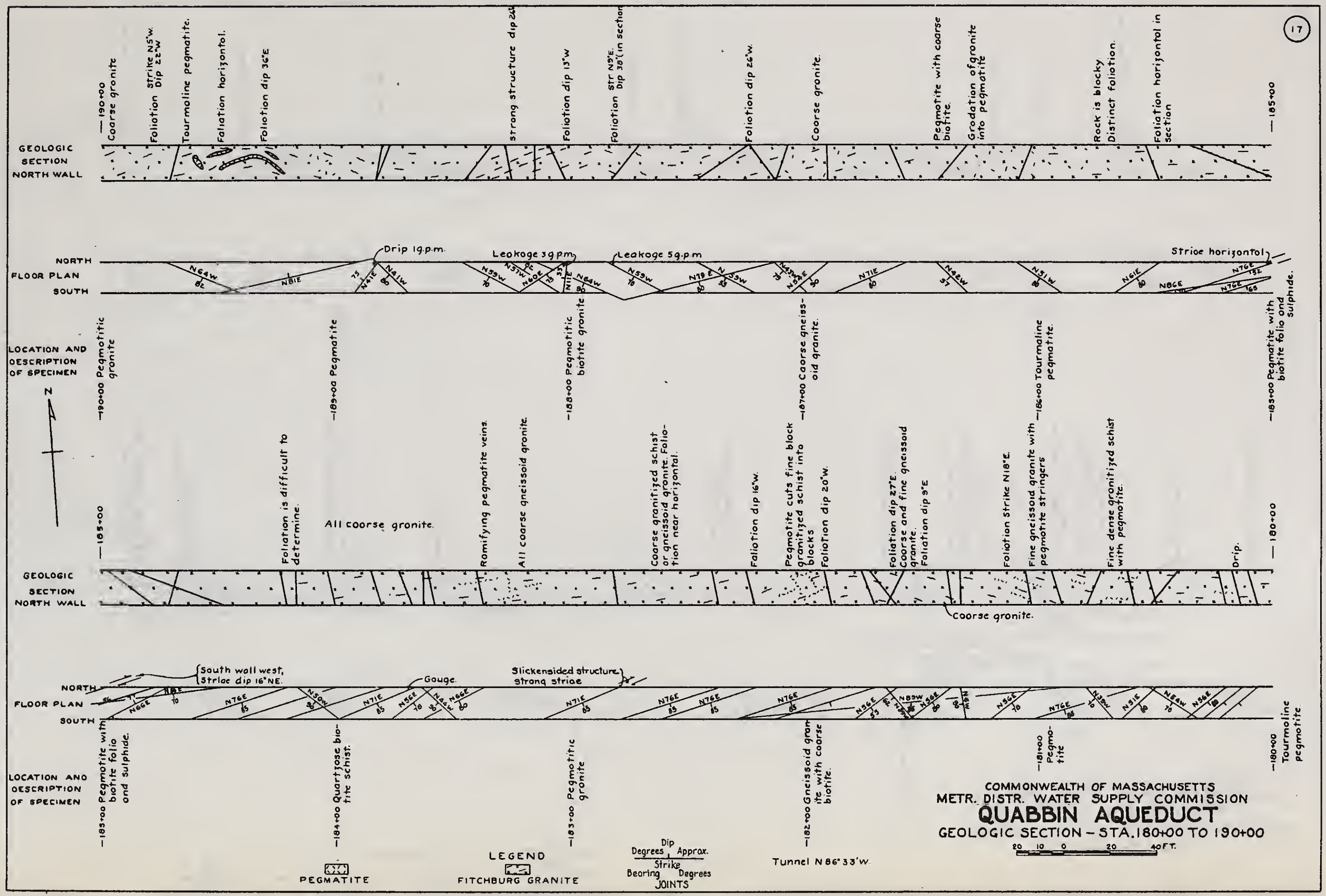
GEOLOGIC SECTION – STA. 180+00 TO 190+00

LEGEND

PEGMATITE

FITCHBURG GRANITE

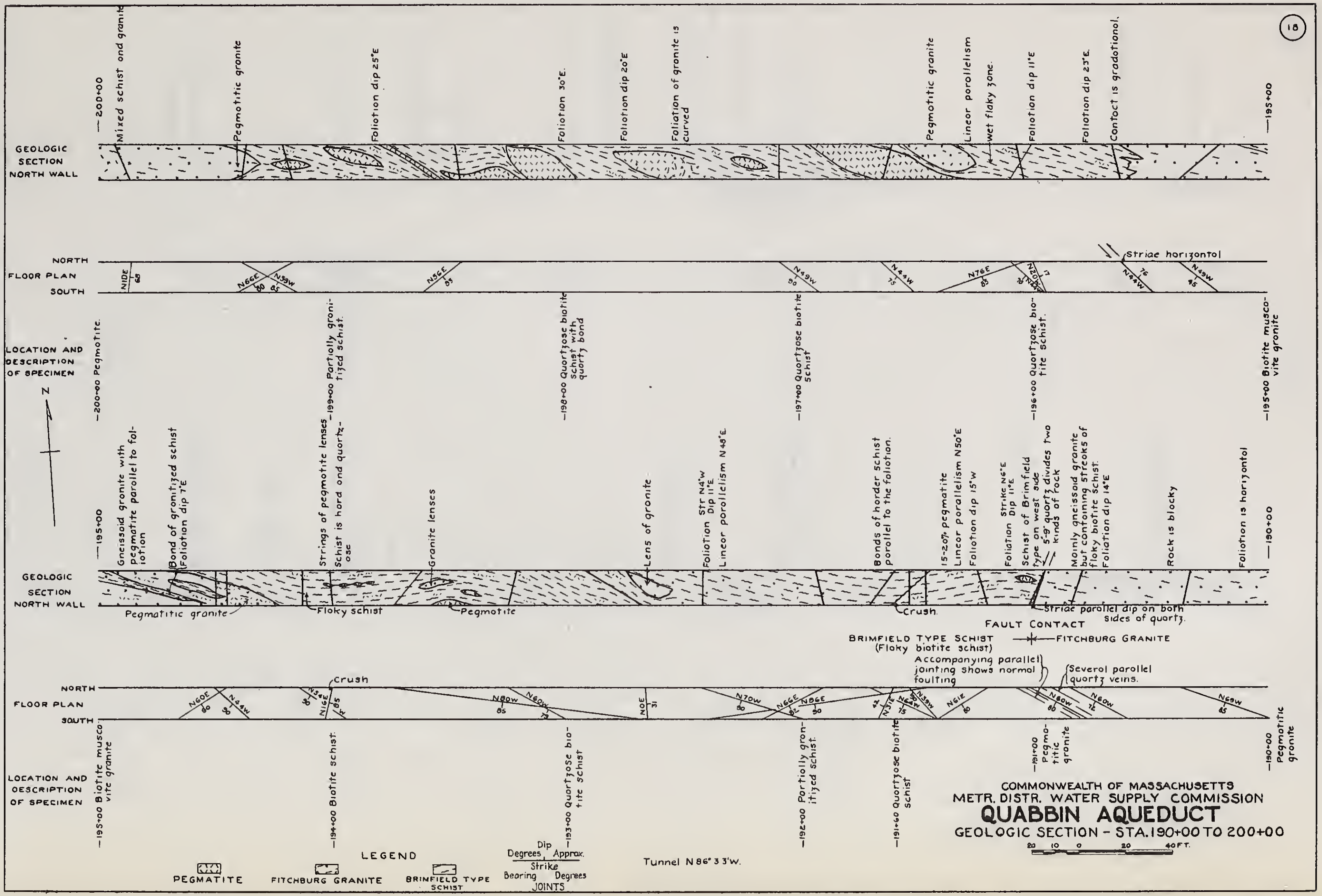
Degrees Dip Approx.
Bearing Strike Degrees
JOINTS


17
GEOLOGIC SECTION NORTH WALL
— 190+00
Coarse granite
Foliation strike N5°W. Dip 22°W
Tourmaline pegmatite.
Foliation horizontal.
Foliation dip 36°E
strong structure dip 26°
Foliation dip 13°W
Foliation str N9°E. Dip 38°(in section
Foliation dip 26°W.
Coarse granite.
Pegmatite with coarse biotite.
Gradation of granite into pegmatite
Rock is blocky Distinct foliation.
Foliation horizontal in section
— 185+00
NORTH
FLOOR PLAN
SOUTH
Drip 1g.p.m.
Leakage 3g.p.m.
Leakage 5g.p.m
Striae horizontal
N64W 82
N81E
N41E 75
N41W 80
N59W 70
N57W
N60E
N11E
N64W 80
N59W 70
N79E 80
N35W 85
N54E
N71E 80
N42W 57
N51W 80
N61E 80
N86E
N76E 52
N76E 65
LOCATION AND DESCRIPTION OF SPECIMEN
—190+00 Pegmatitic granite
—189+00 Pegmatite
—188+00 Pegmatitic biotite granite
—187+00 Coarse gneissoid granite.
—186+00 Tourmaline pegmatite.
—185+00 Pegmatite with biotite folia and sulphide.
N
— 185+00
Foliation is difficult to determine.
All coarse granite.
Ramifying pegmatite veins.
All coarse gneissoid granite.
Coarse granitized schist or gneissoid granite. Foliation near horizontal.
Foliation dip 16°W.
Pegmatite cuts fine block granitized schist into blocks
Foliation dip 20°W.
Foliation dip 27°E.
Coarse and fine gneissoid granite.
Foliation dip 9°E
Foliation strike N18°E.
Fine gneissoid granite with pegmatite stringers
Fine dense granitized schist with pegmatite.
Drip.
— 180+00
Coarse granite.
South wall west, Striae dip 16°NE.
Gouge.
Slickensided structure, strong striae
N66E
N76E 85
N50W 80
N71E 85
N56E 70
N42W
N66E 60
N71E 85
N76E 85
N76E 85
N76E 85
N56E 53
N83W
N56E 60
N31W
N56E 78
N76E
N39W 70
N51E 80
N64W 70
N36E 80
—185+00 Pegmatite with biotite folia and sulphide.
—184+00 Quartzose biotite schist.
—183+00 Pegmatitic granite
—182+00 Gneissoid granite with coarse biotite.
—181+00 Pegmatite
—180+00 Tourmaline pegmatite
LEGEND
PEGMATITE
FITCHBURG GRANITE
Dip Degrees Approx. Strike Bearing Degrees
JOINTS
Tunnel N 86°33'W.
20 10 0 20 40 FT.

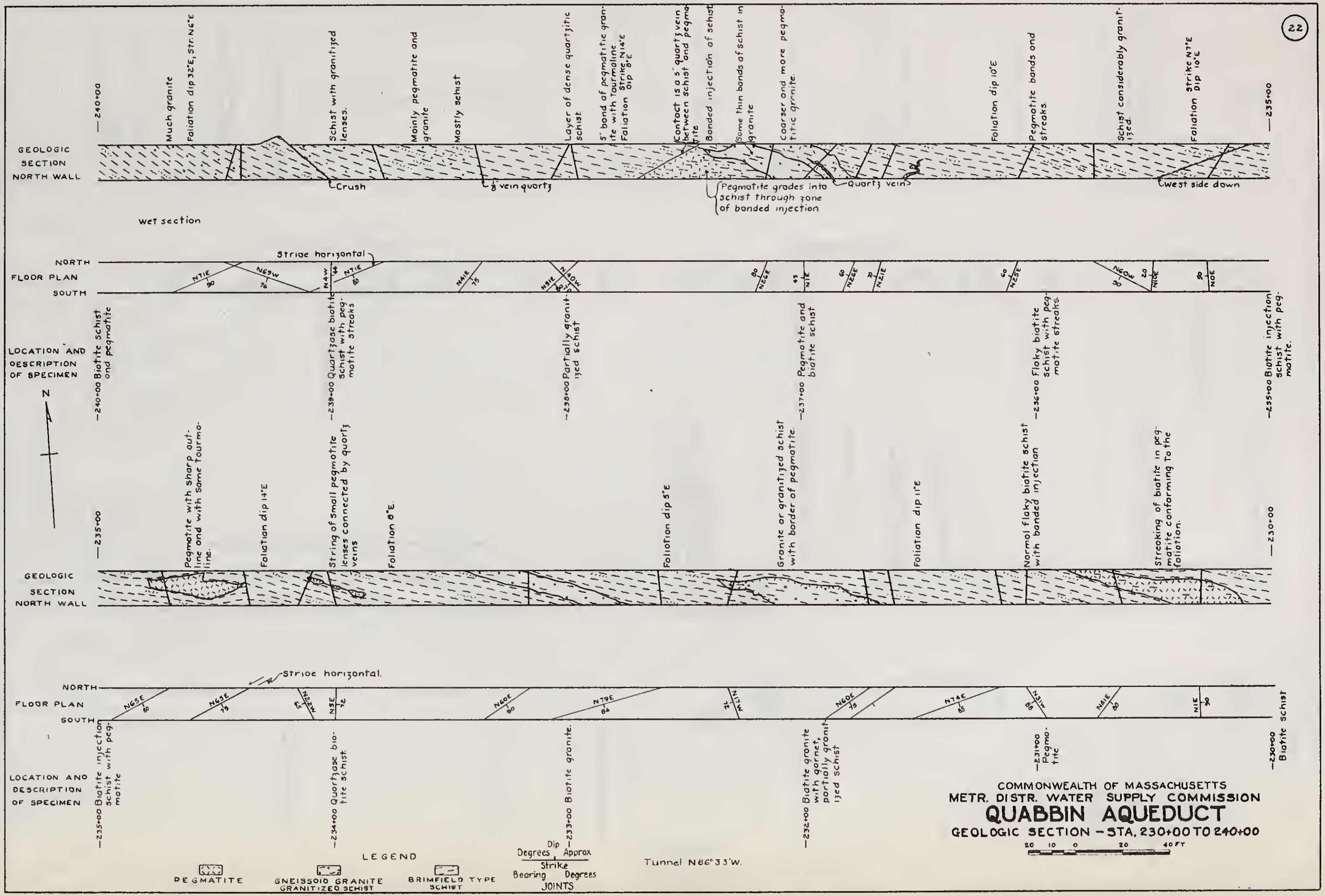
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 180+00 TO 190+00


18
GEOLOGIC SECTION NORTH WALL
—200+00
Mixed schist and granite
Pegmatitic granite
Foliation dip 25°E
Foliation 30°E.
Foliation dip 20°E
Foliation of granite is curved
Pegmatitic granite
Linear parallelism
Wet flaky zone.
Foliation dip 11°E
Foliation dip 23°E.
Contact is gradational.
—195+00
NORTH
FLOOR PLAN
SOUTH
N1OE 68
N66E 80
N39W 85
N56E 85
N49W 90
N44W 75
N76E 85
N20W 17
Striae horizontal
N44W 76
N49W 85
LOCATION AND DESCRIPTION OF SPECIMEN
—200+00 Pegmatite.
—199+00 Partially granitized schist.
—198+00 Quartzose biotite schist with quartz band
—197+00 Quartzose biotite schist
—196+00 Quartzose biotite schist.
—195+00 Biotite muscovite granite
N
—195+00
Gneissoid granite with pegmatite parallel to foliation
Band of granitized schist Foliation dip 7°E
Strings of pegmatite lenses
Schist is hard and quartzose
Granite lenses
Lens of granite
Foliation Str N4°W Dip 11°E
Linear parallelism N48°E.
Bands of harder schist parallel to the foliation.
15-20% pegmatite
Linear parallelism N50°E
Foliation dip 15°W
Foliation Strike N6°E Dip 11°E
Schist of Brimfield type on west side
5-9" quartz divides two kinds of rock
Mainly gneissoid granite but containing streaks of flaky biotite schist.
Foliation dip 14°E
Rock is blocky
Foliation is horizontal
—190+00
GEOLOGIC SECTION NORTH WALL
Pegmatitic granite
Flaky schist
Pegmatite
Crush.
Striae parallel dip on both sides of quartz.
FAULT CONTACT
BRIMFIELD TYPE SCHIST (Flaky biotite schist)
FITCHBURG GRANITE
Accompanying parallel jointing shows normal faulting
Several parallel quartz veins.
NORTH
FLOOR PLAN
SOUTH
Crush
N60E 80
N44W 30
N54W 30
N1GE 85
N80W 85
N60W 73
N0E 31
N70W 80
N66E 82
N86E 30
N31E 42
N44W 75
N39W
N61E 80
N80W 80
N60W 72
N69W 85
LOCATION AND DESCRIPTION OF SPECIMEN
—195+00 Biotite muscovite granite
—194+00 Biotite schist.
—193+00 Quartzose biotite schist
—192+00 Partially granitized schist.
—191+60 Quartzose biotite schist
—191+00 Pegmatitic granite
—190+00 Pegmatitic granite
LEGEND
PEGMATITE
FITCHBURG GRANITE
BRIMFIELD TYPE SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86° 33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION - STA. 190+00 TO 200+00

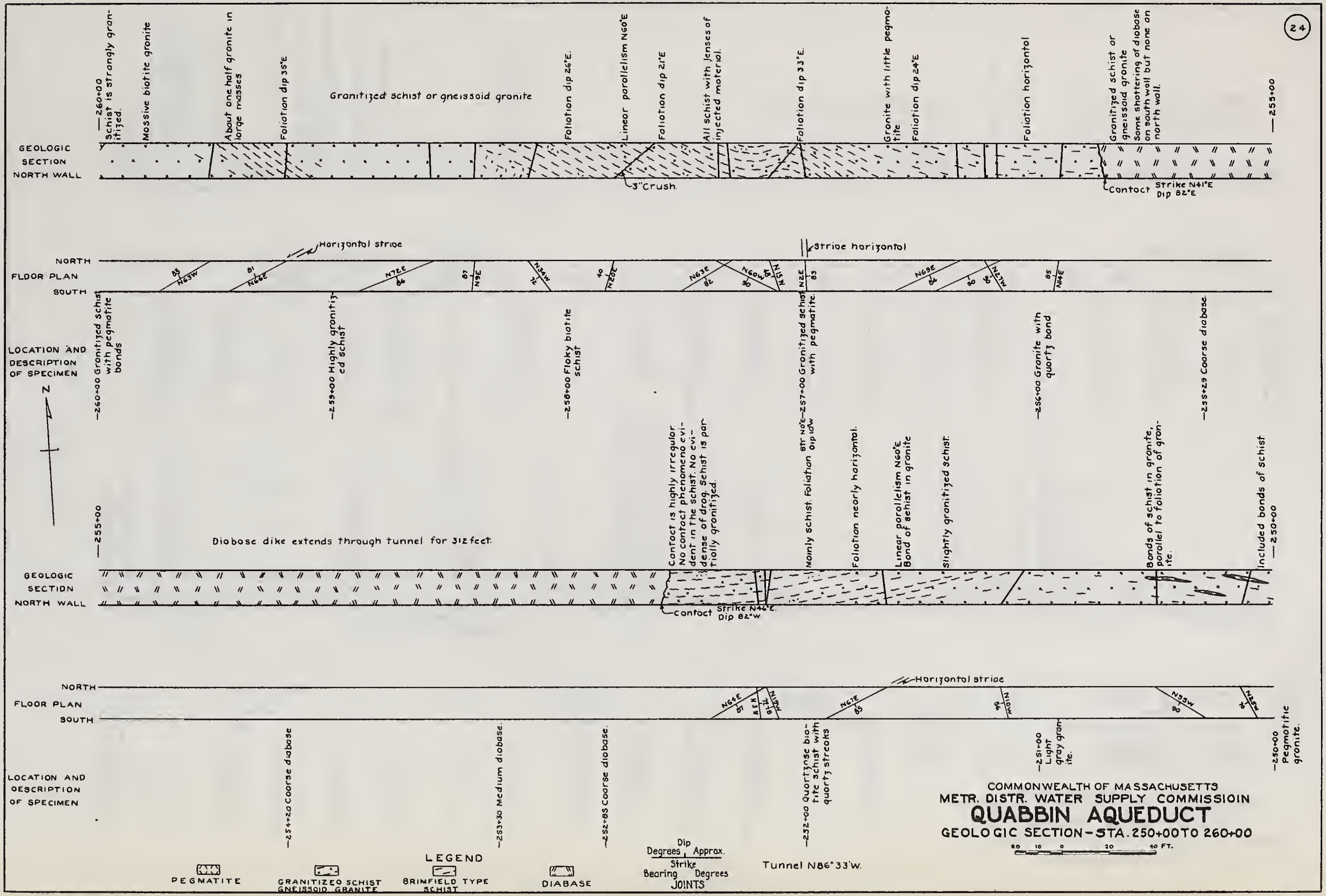


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

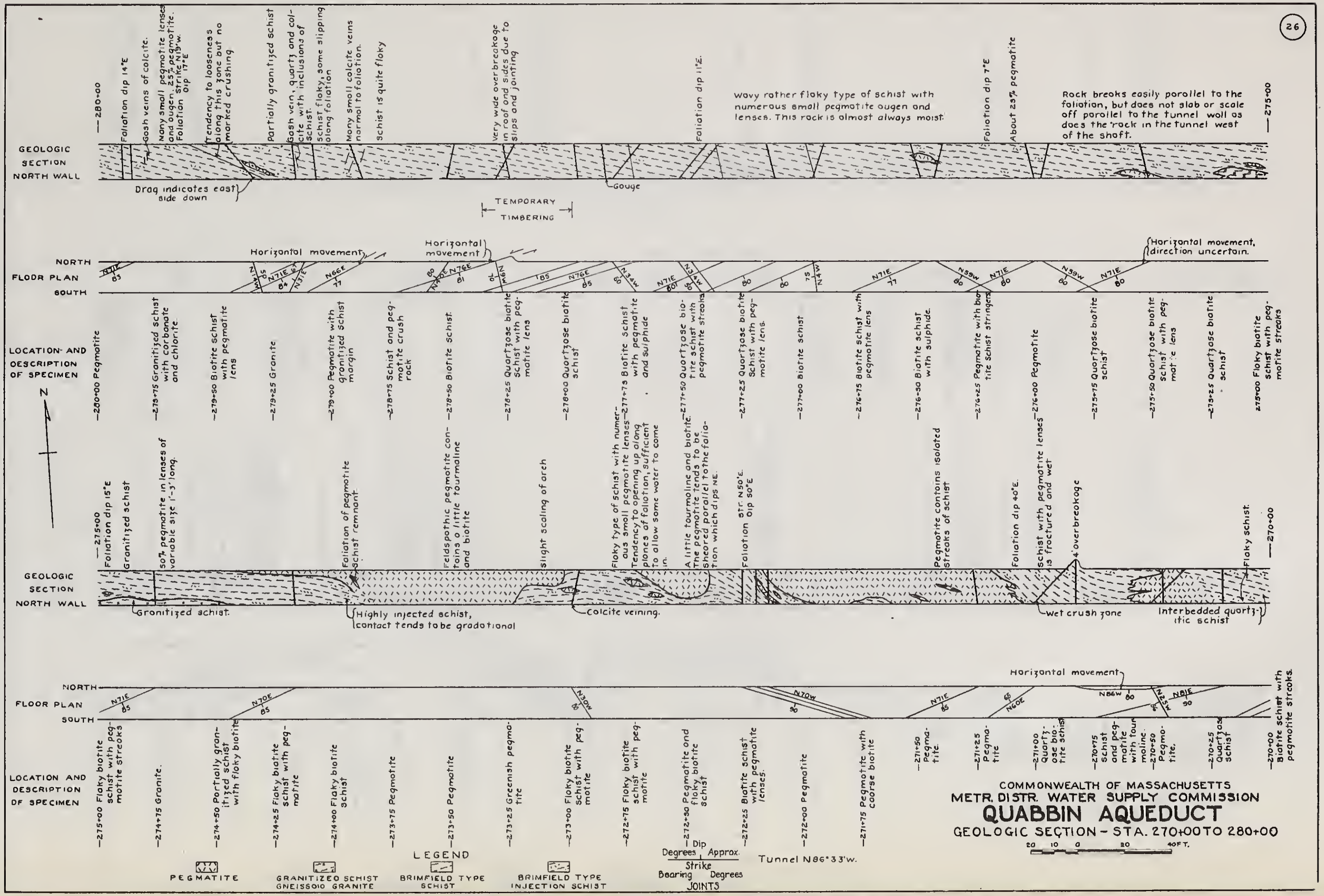
QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 230+00 TO 240+00

20 10 0 20 40 FT
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
240+00
235+00
230+00
Much granite
Foliation dip 32°E, Str. N6°E
Schist with granitized lenses.
Crush
Mainly pegmatite and granite
Mostly schist
1/8" vein quartz
Layer of dense quartzitic schist
5' bond of pegmatitic granite with tourmaline Foliation Strike N14°E Dip 8°E
Contact is a 5' quartz vein between schist and pegmatite
Banded injection of schist
Some thin bands of schist in granite
Pegmatite grades into schist through zone of banded injection
Coarser and more pegmatitic granite.
Quartz vein
Foliation dip 10°E
Pegmatite bands and streaks.
Schist considerably granitized.
Foliation Strike N7°E Dip 10°E
West side down
Wet section
Striae horizontal
N71E 90
N69W 76
N4W 44
N71E 80
N41E 75
N51E
N40W
N26E 80
N1E 43
N26E 60
N21E 70
N25E 60
N60W 80
N16E 20
NOE 90
240+00 Biotite schist and pegmatite
239+00 Quartzose biotite schist with pegmatite streaks
238+00 Partially granitized schist
237+00 Pegmatite and biotite schist
236+00 Flaky biotite schist with pegmatite streaks
235+00 Biotite injection schist with pegmatite.
N
Pegmatite with sharp outline and with some tourmaline.
Foliation dip 14°E
String of small pegmatite lenses connected by quartz veins
Foliation 8°E.
Foliation dip 5°E
Granite or granitized schist with border of pegmatite.
Foliation dip 11°E
Normal flaky biotite schist with banded injection
Streaking of biotite in pegmatite conforming to the foliation.
Striae horizontal.
N65E 60
N65E 75
N22W 65
N5E 72
N60E 80
N79E 84
N17W 72
N60E 75
N74E 65
N31W 88
N41E 80
N1E 90
235+00 Biotite injection schist with pegmatite
234+00 Quartzose biotite schist.
233+00 Biotite granite.
232+00 Biotite granite with garnet, partially granitized schist
231+00 Pegmatite
230+00 Biotite schist
LEGEND
PEGMATITE
GNEISSOID GRANITE GRANITIZED SCHIST
BRIMFIELD TYPE SCHIST
Dip Degrees Approx
Strike
Bearing Degrees
JOINTS
Tunnel N86°33'W.


GEOLOGIC SECTION NORTH WALL
—260+00
Schist is strongly granitized.
Massive biotite granite
About one half granite in large masses
Foliation dip 35°E
Granitized schist or gneissoid granite
Foliation dip 26°E.
Linear parallelism N60°E
Foliation dip 21°E
All schist with lenses of injected material.
Foliation dip 33°E.
Granite with little pegmatite
Foliation dip 24°E
Foliation horizontal
Granitized schist or gneissoid granite
Some shattering of diabase on south wall but none on north wall.
—255+00
3" Crush.
Contact Strike N41°E Dip 82°E
NORTH FLOOR PLAN SOUTH
Horizontal striae
Striae horizontal
N63W 83
N66E 81
N72E 86
N9E 87
N34W 72
N20E 40
N63E 82
N60W 90
N15N 48
N2E 83
N69E 84
N27W 80 86
N4E 85
LOCATION AND DESCRIPTION OF SPECIMEN
—260+00 Granitized schist with pegmatite bands
—259+00 Highly granitized schist
—258+00 Flaky biotite schist
—257+00 Granitized schist with pegmatite.
—256+00 Granite with quartz band
—255+29 Coarse diabase
N
—255+00
Diabase dike extends through tunnel for 312 feet.
Contact is highly irregular No contact phenomena evident in the schist. No evidence of drag. Schist is partially granitized.
Str N0°E Dip 10W
Mainly schist. Foliation
Foliation nearly horizontal.
Linear parallelism N60°E Band of schist in granite
Slightly granitized schist.
Bands of schist in granite, parallel to foliation of granite.
Included bands of schist
—250+00
Contact Strike N46°E. Dip 82°W
Horizontal striae
N64E 51
N3W 72
N15W 81
N67E 85
N10W 86
N35W 80
N25W 70
—254+20 Coarse diabase
—253+30 Medium diabase.
—252+85 Coarse diabase.
—252+00 Quartzose biotite schist with quartz streaks
—251+00 Light gray granite.
—250+00 Pegmatitic granite.
LEGEND
PEGMATITE
GRANITIZED SCHIST GNEISSOID GRANITE
BRIMFIELD TYPE SCHIST
DIABASE
Dip Degrees, Approx.
Strike
Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSIOIN
QUABBIN AQUEDUCT
GEOLOGIC SECTION - STA. 250+00 TO 260+00

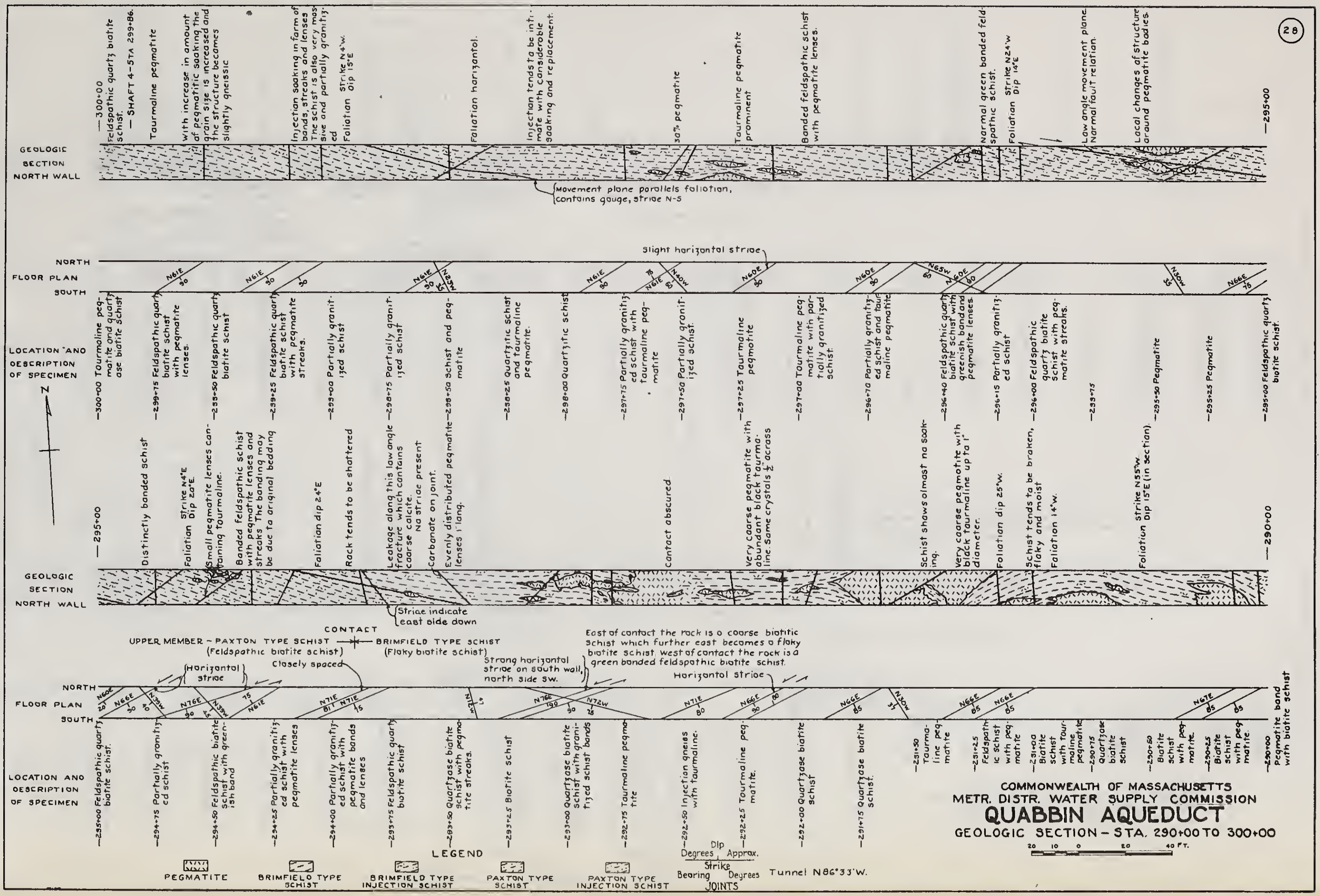


26
GEOLOGIC SECTION NORTH WALL
280+00
Foliation dip 14°E
Gosh veins of colcite.
Many small pegmatite lenses and ougen. 25% pegmatite. Foliation Strike N19°W. Dip 17°E
Tendency to looseness along this zone but no marked crushing
Partially granitized schist
Gosh vein, quartz and colcite with inclusions of schist.
Schist floky, some slipping along foliation
Many small colcite veins normal to foliation.
Schist is quite floky
Very wide overbreakage in roof and sides due to slips and jointing
Foliation dip 11°E.
Wavy rather floky type of schist with numerous small pegmatite ougen and lenses. This rock is almost always moist.
Foliation dip 7°E
About 25% pegmatite
Rock breaks easily parallel to the foliation, but does not slab or scale off parallel to the tunnel wall as does the rock in the tunnel west of the shaft.
275+00
Drag indicates east side down
Gouge
TEMPORARY TIMBERING
NORTH
FLOOR PLAN
SOUTH
Horizontal movement
Horizontal movement
Horizontal movement, direction uncertain.
N71E 83
N14W 75
N71E 84
N31E
N66E 77
N76E 80
N76E 81
N6W 70
85
N76E 85
N34W 80
N71E 80
N34W 85
80
80
75 N4W
N71E 77
N59W 80
N71E 80
N59W 80
N71E 80
LOCATION AND DESCRIPTION OF SPECIMEN
N
280+00 Pegmatite
279+75 Granitized schist with carbonate and chlorite.
279+50 Biotite schist with pegmatite lens
279+25 Granite
279+00 Pegmatite with granitized schist margin
278+75 Schist and pegmatite crush rock
278+50 Biotite schist.
278+25 Quartzose biotite schist with pegmatite lens
278+00 Quartzose biotite schist
277+75 Biotite schist with pegmatite and sulphide
277+50 Quartzose biotite schist with pegmatite streaks
277+25 Quartzose biotite schist with pegmatite lens.
277+00 Biotite schist
276+75 Biotite schist with pegmatite lens
276+50 Biotite schist with sulphide.
276+25 Pegmatite with biotite schist stringers
276+00 Pegmatite
275+75 Quartzose biotite schist
275+50 Quartzose biotite schist with pegmatite lens
275+25 Quartzose biotite schist
275+00 Floky biotite schist with pegmatite streaks
275+00
Foliation dip 15°E
Granitized schist
50% pegmatite in lenses of variable size 1'-3' long.
Foliation of pegmatite schist remnant.
Feldspathic pegmatite contains a little tourmaline and biotite
Slight scaling of arch
Floky type of schist with numerous small pegmatite lenses. Tendency to opening up along planes of foliation, sufficient to allow some water to come in.
A little tourmaline and biotite. The pegmatite tends to be sheared parallel to the foliation which dips NE.
Foliation str. N50°E. Dip 50°E
Pegmatite contains isolated streaks of schist
Foliation dip 40°E.
Schist with pegmatite lenses is fractured and wet
4' overbreakage
Floky schist.
270+00
GEOLOGIC SECTION NORTH WALL
Granitized schist.
Highly injected schist, contact tends to be gradational
Calcite veining.
Wet crush zone
Interbedded quartzitic schist
NORTH
FLOOR PLAN
SOUTH
Horizontal movement
N71E 85
N70E 85
N30W 80
N70W 90
N71E 85
N60E 65
N86W 80
N25W 80
N81E 90
LOCATION AND DESCRIPTION OF SPECIMEN
275+00 Floky biotite schist with pegmatite streaks
274+75 Granite.
274+50 Partially granitized schist with floky biotite
274+25 Floky biotite schist with pegmatite
274+00 Floky biotite schist
273+75 Pegmatite
273+50 Pegmatite
273+25 Greenish pegmatite
273+00 Floky biotite schist with pegmatite
272+75 Floky biotite schist with pegmatite
272+50 Pegmatite and floky biotite schist
272+25 Biotite schist with pegmatite lenses.
272+00 Pegmatite
271+75 Pegmatite with coarse biotite
271+50 Pegmatite.
271+25 Pegmatite
271+00 Quartzose biotite schist
270+75 Schist and pegmatite with tourmaline.
270+50 Pegmatite.
270+25 Quartzose schist
270+00 Biotite schist with pegmatite streaks.
LEGEND
PEGMATITE
GRANITIZED SCHIST GNEISSOID GRANITE
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

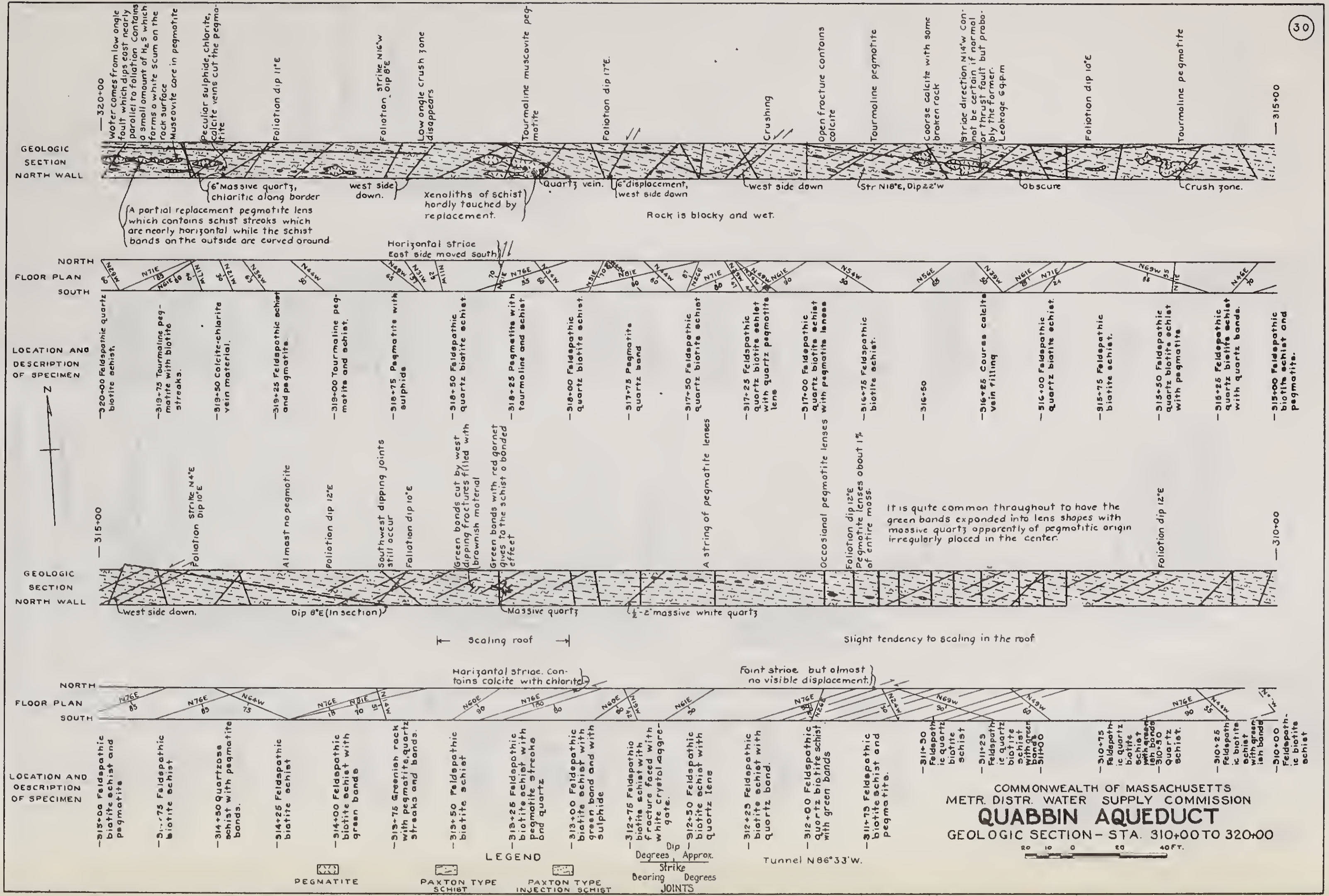
GEOLOGIC SECTION - STA. 270+00 TO 280+00


28
GEOLOGIC SECTION NORTH WALL
—300+00
Feldspathic quartz biotite schist.
— SHAFT 4–STA 299+86.
Tourmaline pegmatite
With increase in amount of pegmatitic soaking the grain size is increased and the structure becomes slightly gneissic
Injection soaking in form of bands, streaks and lenses The schist is also very massive and partially granitized
Foliation Strike N4°W. Dip 15°E
Foliation horizontal.
Injection tends to be intimate with considerable soaking and replacement.
30% pegmatite
Tourmaline pegmatite prominent
Banded feldspathic schist with pegmatite lenses.
Normal green banded feldspathic schist.
Foliation Strike N24°W Dip 14°E
Low angle movement plane. Normal fault relation.
Local changes of structure around pegmatite bodies.
—295+00
Movement plane parallels foliation, contains gouge, striae N-S
Slight horizontal striae
NORTH
FLOOR PLAN
SOUTH
N61E 90
N61E 90
90
N61E 90 35 N25W
N61E 90
75 N61E 85 N40W
N60E 90
N60E 90
N65W 80 N60E 90
N30W 35
N66E 75
LOCATION AND DESCRIPTION OF SPECIMEN
—300+00 Tourmaline pegmatite and quartzose biotite schist
—299+75 Feldspathic quartz biotite schist with pegmatite lenses.
—299+50 Feldspathic quartz biotite schist
—299+25 Feldspathic quartz biotite schist with pegmatite streaks.
—299+00 Partially granitized schist
—298+75 Partially granitized schist
—298+50 Schist and pegmatite
—298+25 Quartzitic schist and tourmaline pegmatite.
—298+00 Quartzitic schist
—297+75 Partially granitized schist with tourmaline pegmatite
—297+50 Partially granitized schist.
—297+25 Tourmaline pegmatite
—297+00 Tourmaline pegmatite with partially granitized schist.
—296+70 Partially granitized schist and tourmaline pegmatite
—296+40 Feldspathic quartz biotite schist with greenish band and pegmatite lenses.
—296+15 Partially granitized schist
—296+00 Feldspathic quartz biotite schist with pegmatite streaks.
—295+75
—295+50 Pegmatite
—295+25 Pegmatite
—295+00 Feldspathic quartz biotite schist.
N
GEOLOGIC SECTION NORTH WALL
— 295+00
Distinctly banded schist
Foliation Strike N4°E Dip 20°E.
Small pegmatite lenses containing tourmaline.
Banded feldspathic schist with pegmatite lenses and streaks The banding may be due to original bedding
Foliation dip 24°E
Rock tends to be shattered
Leakage along this low angle fracture which contains coarse calcite. No striae present
Carbonate on joint.
Evenly distributed pegmatite lenses 1' long.
Contact obscured
Very coarse pegmatite with abundant black tourmaline. Some crystals ½" across
Schist shows almost no soaking.
Very coarse pegmatite with black tourmaline up to 1" diameter.
Foliation dip 25°W.
Schist tends to be broken, flaky and moist
Foliation 14°W.
Foliation Strike N55°W. Dip 15°E (in section).
— 290+00
Striae indicate east side down
CONTACT
UPPER MEMBER – PAXTON TYPE SCHIST (Feldspathic biotite schist)
BRIMFIELD TYPE SCHIST (Flaky biotite schist)
Horizontal striae
Closely spaced
Strong horizontal striae on south wall, north side SW.
East of contact the rock is a coarse biotitic schist which further east becomes a flaky biotite schist. West of contact the rock is a green banded feldspathic biotite schist.
Horizontal striae
NORTH
FLOOR PLAN
SOUTH
N60E 20 N66E 30 40 N39W
N76E 90 45 N39W 75 N61E
N71E 81 N71E 75
N12W 47
N76E 190 90 N72W 75
N71E 80
N66E 90 80
N66E 85
N30W 35
N66E 85 N66E 85
N67E 85 85
LOCATION AND DESCRIPTION OF SPECIMEN
—295+00 Feldspathic quartz biotite schist.
—294+75 Partially granitized schist
—294+50 Feldspathic biotite schist with greenish band
—294+25 Partially granitized schist with pegmatite lenses
—294+00 Partially granitized schist with pegmatite bands and lenses
—293+75 Feldspathic quartz biotite schist
—293+50 Quartzose biotite schist with pegmatite streaks.
—293+25 Biotite schist
—293+00 Quartzose biotite schist with granitized schist bands
—292+75 Tourmaline pegmatite
—292+50 Injection gneiss with tourmaline.
—292+25 Tourmaline pegmatite.
—292+00 Quartzose biotite schist
—291+75 Quartzose biotite schist.
—291+50 Tourmaline pegmatite
—291+25 Feldspathic schist with pegmatite
—291+00 Biotite schist with tourmaline pegmatite
—290+75 Quartzose biotite schist
—290+60 Biotite schist with pegmatite.
—290+25 Biotite schist with pegmatite.
—290+00 Pegmatite band with biotite schist
LEGEND
PEGMATITE
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PAXTON TYPE SCHIST
PAXTON TYPE INJECTION SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

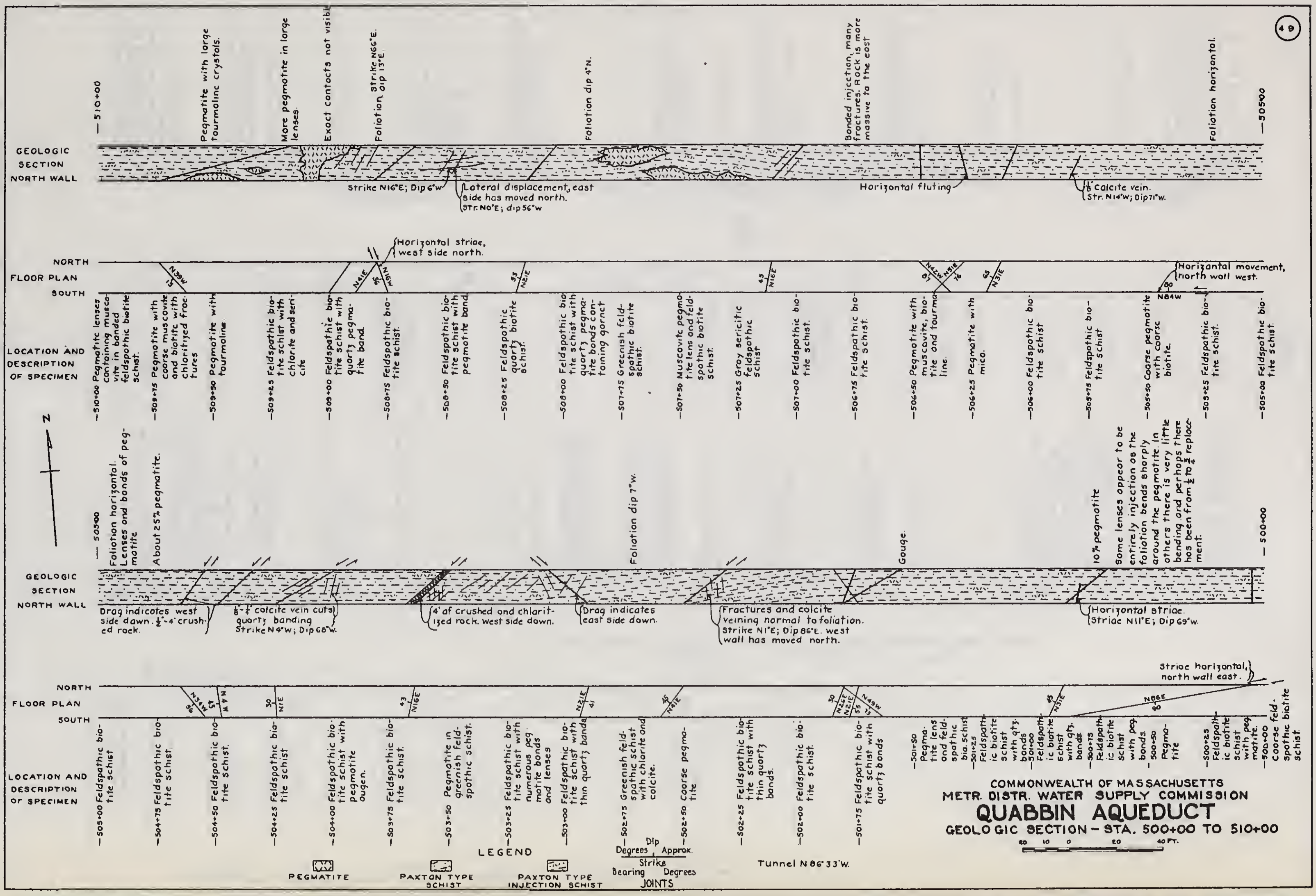
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 290+00 TO 300+00


30
GEOLOGIC SECTION NORTH WALL
320+00
Water comes from low angle fault which dips east nearly parallel to foliation. Contains a small amount of H_2S which forms a white scum on the rock surface
Muscovite core in pegmatite
Peculiar sulphide, chlorite, calcite veins cut the pegmatite
Foliation dip 11°E
Foliation, strike N16°W, dip 8°E
Low angle crush zone disappears
Tourmaline muscovite pegmatite
Foliation dip 17°E.
Crushing
Open fracture contains calcite
Tourmaline pegmatite
Coarse calcite with some broken rock
Striae direction N14°W. Cannot be certain if normal or thrust fault but probably the former. Leakage 6 g.p.m
Foliation dip 10°E
Tourmaline pegmatite
315+00
6" Massive quartz, chloritic along border
West side down.
Xenoliths of schist hardly touched by replacement.
Quartz vein.
6" displacement, west side down
West side down
Str N18°E, Dip 22°W
Obscure
Crush zone.
A partial replacement pegmatite lens which contains schist streaks which are nearly horizontal while the schist bands on the outside are curved around
Rock is blocky and wet.
Horizontal striae East side moved South
NORTH
FLOOR PLAN
SOUTH
N28W 65
N71E 85
N61E 60 80
M11N
M12N 80
N34W 65
N64W 50
N69W 65
N31W 15
M11N 25
70
N21E
N76E 35 60
N34W
N31E 70
N81E 80
N44W 60
67
N26E
N71E 80
N39W
N34W
N49W
N61E 90
N54W 30
N56E 65
N39W 55
N61E 81
N71E 24
N69W 55 86
N71E
N46E 70
LOCATION AND DESCRIPTION OF SPECIMEN
Z
320+00 Feldspathic quartz biotite schist.
319+75 Tourmaline pegmatite with biotite streaks.
319+50 Calcite-chlorite vein material.
319+25 Feldspathic schist and pegmatite.
319+00 Tourmaline pegmatite and schist.
318+75 Pegmatite with sulphide
318+50 Feldspathic quartz biotite schist
318+25 Pegmatite with tourmaline and schist
318+00 Feldspathic quartz biotite schist.
317+75 Pegmatite quartz band
317+50 Feldspathic quartz biotite schist
317+25 Feldspathic quartz biotite schist with quartz pegmatite lens
317+00 Feldspathic quartz biotite schist with pegmatite lenses
316+75 Feldspathic biotite schist.
316+50
316+25 Course calcite vein filling
316+00 Feldspathic quartz biotite schist.
315+75 Feldspathic biotite schist.
315+50 Feldspathic quartz biotite schist with pegmatite
315+25 Feldspathic quartz biotite schist with quartz bands.
315+00 Feldspathic biotite schist and pegmatite.
GEOLOGIC SECTION NORTH WALL
315+00
Foliation strike N4°E dip 10°E
Almost no pegmatite
Foliation dip 12°E
Southwest dipping joints still occur
Foliation dip 10°E
Green bands cut by west dipping fractures filled with brownish material
Green bands with red garnet gives to the schist a banded effect
A string of pegmatite lenses
Occasional pegmatite lenses
Foliation dip 12°E
Pegmatite lenses about 1% of entire mass.
It is quite common throughout to have the green bands expanded into lens shapes with massive quartz apparently of pegmatitic origin irregularly placed in the center.
Foliation dip 12°E
310+00
West side down.
Dip 8°E (In section)
Massive quartz
½-2" massive white quartz
Scaling roof
Slight tendency to scaling in the roof
Horizontal striae. Contains calcite with chlorite
Faint striae but almost no visible displacement.
NORTH
FLOOR PLAN
SOUTH
N76E 85
N76E 85
N64W 75
N76E 18
N81E 10
N14W 15
N60E 80
N76E 180 80
N60E 80
M61N 24
N61E 30
N76E 30
N26E
N24W 30
N69W 90
N49W 85
N76E 90
N44W 55
LOCATION AND DESCRIPTION OF SPECIMEN
315+00 Feldspathic biotite schist and pegmatite
314+75 Feldspathic biotite schist
314+50 Quartzose schist with pegmatite bands.
314+25 Feldspathic biotite schist
314+00 Feldspathic biotite schist with green bands
313+75 Greenish rock with pegmatite, quartz streaks and bands.
313+50 Feldspathic biotite schist
313+25 Feldspathic biotite schist with pegmatite streaks and quartz
313+00 Feldspathic biotite schist with green band and with sulphide
312+75 Feldspathic biotite schist with fracture faced with white crystal aggregate.
312+50 Feldspathic biotite schist with quartz lens
312+25 Feldspathic biotite schist with quartz band.
312+00 Feldspathic quartz biotite schist with green bands
311+75 Feldspathic biotite schist and pegmatite.
311+50 Feldspathic quartz biotite schist
311+25 Feldspathic quartz biotite schist with greenish bands
311+00
310+75 Feldspathic quartz biotite schist with greenish bands
310+50 Quartz schist.
310+25 Feldspathic biotite schist with greenish bands
310+00 Feldspathic biotite schist
LEGEND
PEGMATITE
PAXTON TYPE SCHIST
PAXTON TYPE INJECTION SCHIST
Dip
Degrees
Approx.
Strike
Bearing
Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

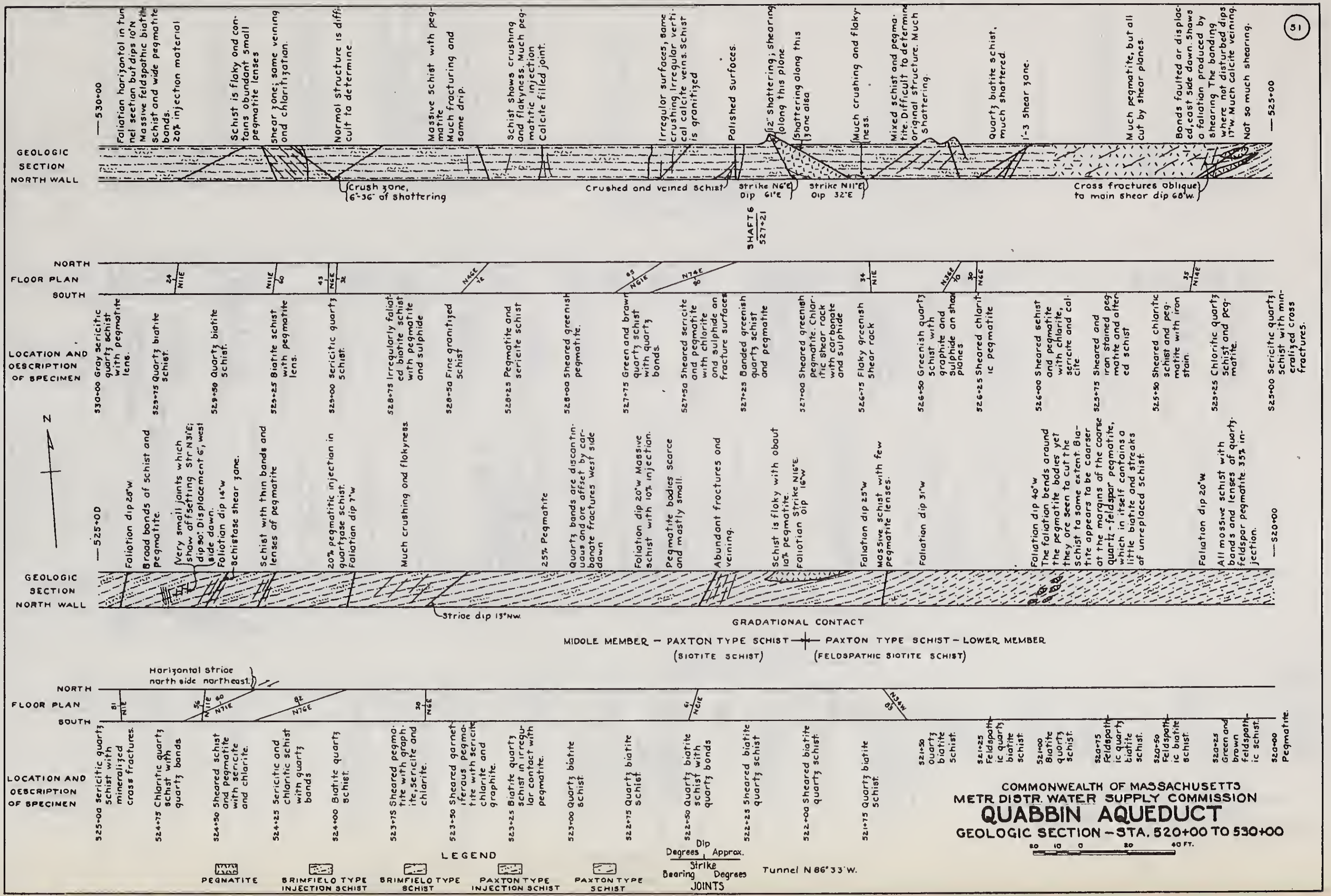
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 310+00 TO 320+00


49
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
510+00
Pegmatite with large tourmaline crystals.
More pegmatite in large lenses.
Exact contacts not visible
Foliation Strike N66°E. dip 13°E.
Foliation dip 4°N.
Banded injection, many fractures. Rock is more massive to the east
Foliation horizontal.
505+00
Strike N16°E; Dip 6°W
Lateral displacement, east side has moved north. Str. N0°E; dip 56°W
Horizontal fluting
⅛ Calcite vein. Str. N14°W; Dip 71°W.
Horizontal striae, west side north.
Horizontal movement, north wall west.
N39W 15
N4IE
N16W 36
N21E 55
N16E 43
N42W 67
N31E 76
N31E 65
N84W 80
510+00 Pegmatite lenses containing muscovite in banded feldspathic biotite schist.
509+75 Pegmatite with coarse muscovite and biotite with chloritized fractures
509+50 Pegmatite with tourmaline
509+25 Feldspathic biotite schist with chlorite and sericite
509+00 Feldspathic biotite schist with quartz pegmatite band.
508+75 Feldspathic biotite schist.
508+50 Feldspathic biotite schist with pegmatite band.
508+25 Feldspathic quartz biotite schist.
508+00 Feldspathic biotite schist with quartz pegmatite bands containing garnet
507+75 Greenish feldspathic biotite schist.
507+50 Muscovite pegmatite lens and feldspathic biotite schist.
507+25 Gray sericitic feldspathic schist
507+00 Feldspathic biotite schist.
506+75 Feldspathic biotite schist.
506+50 Pegmatite with muscovite, biotite and tourmaline.
506+25 Pegmatite with mica.
506+00 Feldspathic biotite schist
505+75 Feldspathic biotite schist
505+50 Coarse pegmatite with coarse biotite.
505+25 Feldspathic biotite schist.
505+00 Feldspathic biotite schist.
N
505+00
Foliation horizontal. Lenses and bands of pegmatite
About 25% pegmatite.
Foliation dip 7°W.
Gouge.
10% pegmatite
Some lenses appear to be entirely injection as the foliation bends sharply around the pegmatite. In others there is very little bending and perhaps there has been from ½ to ¾ replacement.
500+00
Drag indicates west side down. ½"-4" crushed rock.
⅛-¼ calcite vein cuts quartz banding Strike N4°W; Dip 68°W.
4' of crushed and chloritized rock. West side down.
Drag indicates east side down.
Fractures and calcite veining normal to foliation. Strike N1°E; Dip 86°E. west wall has moved north.
Horizontal striae. Striae N11°E; Dip 69°W.
Striae horizontal, north wall east.
N34W 56
N4W 43
N1E 30
N16E 43
N21E 41
N16E 45
N26E 30
N21E 55
N49W 54
N31E 45
N86E 80
505+00 Feldspathic biotite schist
504+75 Feldspathic biotite schist.
504+50 Feldspathic biotite schist.
504+25 Feldspathic biotite schist
504+00 Feldspathic biotite schist with pegmatite augen.
503+75 Feldspathic biotite schist.
503+50 Pegmatite in greenish feldspathic schist.
503+25 Feldspathic biotite schist with numerous pegmatite bands and lenses
503+00 Feldspathic biotite schist with thin quartz bands
502+75 Greenish feldspathic schist with chlorite and calcite.
502+50 Coarse pegmatite
502+25 Feldspathic biotite schist with thin quartz bands.
502+00 Feldspathic biotite schist.
501+75 Feldspathic biotite schist with quartz bands
501+50 Pegmatite lens and feldspathic bio. schist
501+25 Feldspathic biotite schist with qtz. bands
501+00 Feldspathic biotite schist with qtz. bands
500+75 Feldspathic biotite schist with peg. bands.
500+50 Pegmatite
500+25 Feldspathic biotite schist with pegmatite.
500+00 Coarse feldspathic biotite schist.
LEGEND
PEGMATITE
PAXTON TYPE SCHIST
PAXTON TYPE INJECTION SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86° 33' W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 500+00 TO 510+00


(51)
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
— 530+00
Foliation horizontal in tunnel section but dips 10°N Massive feldspathic biotite schist and wide pegmatite bands. 20% injection material
Schist is flaky and contains abundant small pegmatite lenses
Shear zone; some veining and chloritization.
Normal structure is difficult to determine.
Massive schist with pegmatite Much fracturing and same drip.
Schist shows crushing and flakyness. Much pegmatitic injection Calcite filled joint.
Irregular surfaces, some crushing Irregular vertical calcite veins. Schist is granitized
Polished surfaces.
12" Shattering; shearing along this plane
Shattering along this zone also
Much crushing and flakyness.
Mixed schist and pegmatite. Difficult to determine original structure. Much shattering.
Quartz biotite schist, much shattered.
1'-3 Shear zone.
Much pegmatite, but all cut by shear planes.
Bands faulted or displaced, east side down. Shows a foliation produced by shearing The banding where not disturbed dips 17°w. Much calcite veining.
Not so much shearing.
— 525+00
Crush zone, 6"-36" of shattering
Crushed and veined schist
Strike N6°E Dip 61°E
Strike N11°E Dip 32°E
Cross fractures oblique to main shear dip 68°w.
SHAFT 6 527+21
24 N1E
N1E 60
43 N6E 32
N46E 72
65 N61E
N74E 80
34 N1E
N36E 70
30 N6E
35 N14E
N
— 525+00
Foliation dip 28°w
Broad bands of schist and pegmatite.
Very small joints which show offsetting Str N31E; dip 90° Displacement 6", west side down.
Foliation dip 14°w
Schistose shear zone.
Schist with thin bands and lenses of pegmatite
20% pegmatitic injection in quartzose schist. Foliation dip 7°w
Much crushing and flakyness
Striae dip 13°NW.
25% Pegmatite
Quartz bands are discontinuous and are offset by carbonate fractures West side down
Foliation dip 20°w Massive schist with 10% injection.
Pegmatite bodies scarce and mostly small.
Abundant fractures and veining.
Schist is flaky with about 10% pegmatite.
Foliation Strike N16°E Dip 16°W
Foliation dip 25°w
Massive schist with few pegmatite lenses.
Foliation dip 31°w
Foliation dip 40°w The foliation bends around the pegmatite bodies yet they are seen to cut the schist to same extent. Biotite appears to be coarser at the margins of the coarse quartz-feldspar pegmatite, which in itself contains a little biotite and streaks of unreplaced schist.
Foliation dip 20°w
All massive schist with bands and lenses of quartz-feldspar pegmatite. 35% injection.
— 520+00
GRADATIONAL CONTACT
MIDDLE MEMBER — PAXTON TYPE SCHIST (SIOTITE SCHIST)
PAXTON TYPE SCHIST — LOWER MEMBER (FELDSPATHIC SIOTITE SCHIST)
Horizontal striae north side northeast.
81 N1E
56 N1E 60 N71E
82 N76E
30 N6E
61 N61E
N34W 85
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
PAXTON TYPE INJECTION SCHIST
PAXTON TYPE SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86° 33' W.
20 10 0 20 40 FT.

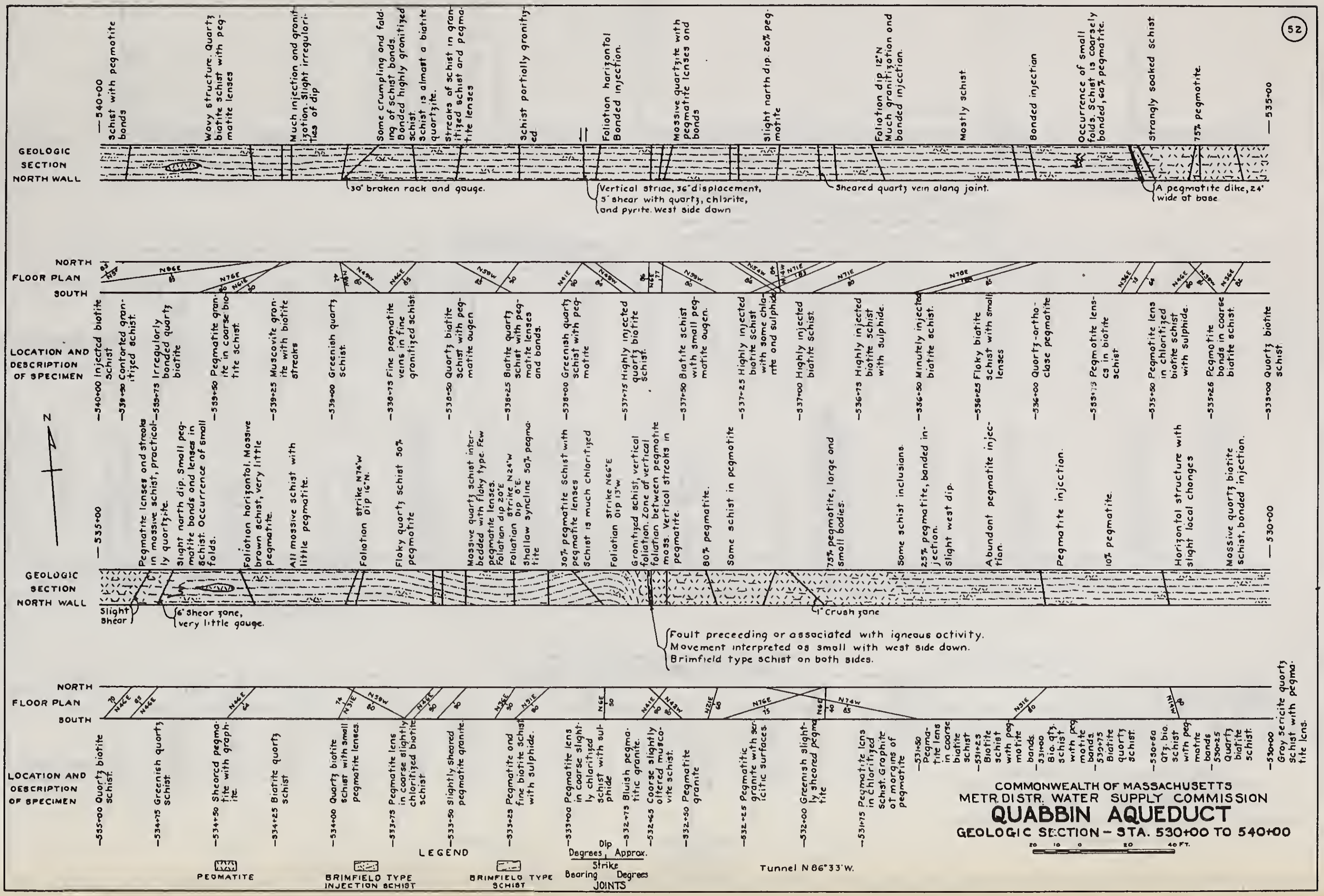
COMMONWEALTH OF MASSACHUSETTS
METR DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

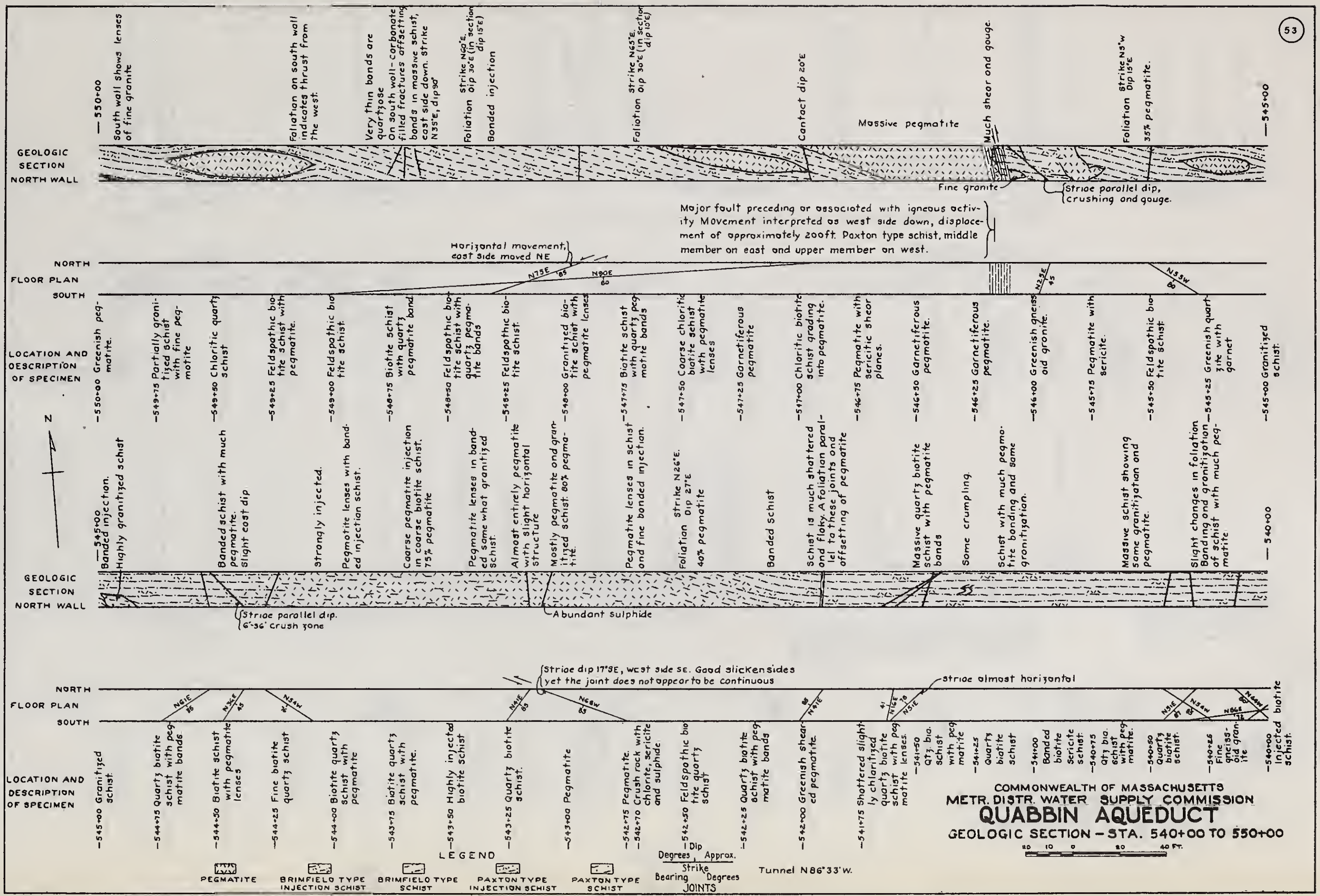
GEOLOGIC SECTION — STA. 520+00 TO 530+00

LOCATION AND DESCRIPTION OF SPECIMEN	
530+00	Gray sericitic quartz schist with pegmatite lens.
529+75	Quartz biotite schist.
529+50	Quartz biotite schist.
529+25	Biotite schist with pegmatite lens.
529+00	Sericitic quartz schist.
528+75	Irregularly foliated biotite schist with pegmatite and sulphide
528+50	Fine granitized schist
528+25	Pegmatite and sericite schist
528+00	Sheared greenish pegmatite.
527+75	Green and brown quartz schist with quartz bands.
527+50	Sheared sericite and pegmatite with chlorite and sulphide on fracture surfaces
527+25	Banded greenish quartz schist and pegmatite
527+00	Sheared greenish pegmatite. Chloritic shear rock with carbonate and sulphide
526+75	Flaky greenish shear rock
526+50	Greenish quartz schist with graphite and sulphide on shear planes.
526+25	Sheared chloritic pegmatite
526+00	Sheared schist and pegmatite with chlorite, sericite and calcite
525+75	Sheared and iron stained pegmatite and altered schist
525+50	Sheared chloritic schist and pegmatite with iron stain.
525+25	Chloritic quartz schist and pegmatite.
525+00	Sericitic quartz schist with mineralized cross fractures.

LOCATION AND DESCRIPTION OF SPECIMEN	
525+00	Sericitic quartz schist with mineralized cross fractures.
524+75	Chloritic quartz schist with quartz bands.
524+50	Sheared schist and pegmatite with sericite and chlorite.
524+25	Sericitic and chloritic schist with quartz bands
524+00	Biotite quartz schist.
523+75	Sheared pegmatite with graphite, sericite and chlorite.
523+50	Sheared garnetiferous pegmatite with sericite chlorite and graphite.
523+25	Biotite quartz schist in irregular contact with pegmatite.
523+00	Quartz biotite schist.
522+75	Quartz biotite schist.
522+50	Quartz biotite schist with quartz bands
522+25	Sheared biotite quartz schist
522+00	Sheared biotite quartz schist.
521+75	Quartz biotite schist.
521+50	Quartz biotite schist.
521+25	Feldspathic quartz biotite schist.
521+00	Biotite quartz schist.
520+75	Feldspathic quartz biotite schist.
520+50	Feldspathic biotite schist.
520+25	Green and brown feldspathic schist.
520+00	Pegmatite.


52
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
540+00
Schist with pegmatite bonds
Wavy structure. Quartz biotite schist with pegmatite lenses
Much injection and granitization. Slight irregularities of dip
Some crumpling and folding of schist bonds. Bonded highly granitized schist. Schist is almost a biotite quartzite.
Streaks of schist in granitized schist and pegmatite lenses
Schist partially granitized
Foliation horizontal Bonded injection.
Massive quartzite with pegmatite lenses and bonds
Slight north dip. 20% pegmatite
Foliation dip 12°N Much granitization and banded injection.
Mostly schist.
Bonded injection
Occurrence of small folds. Schist is coarsely bonded, 60% pegmatite.
Strongly soaked schist
75% pegmatite.
535+00
30° broken rock and gauge.
Vertical striae, 36° displacement, 5' shear with quartz, chlorite, and pyrite. West side down
Sheared quartz vein along joint.
A pegmatite dike, 24' wide at base
N86E
N76E
N61E
N49W
N46E
N59W
N61E
N49W
N6E
N39W
N54W
N71E
N71E
N78E
N36E
N46E
N39W
N36E
540+00 Injected biotite schist
539+90 Contorted granitized schist.
539+75 Irregularly bonded quartz biotite
539+50 Pegmatite granite in coarse biotite schist.
539+25 Muscovite granite with biotite streaks
539+00 Greenish quartz schist.
538+75 Fine pegmatite veins in fine granitized schist.
538+50 Quartz biotite schist with pegmatite augen
538+25 Biotite quartz schist with pegmatite lenses and bands.
538+00 Greenish quartz schist with pegmatite
537+75 Highly injected quartz biotite schist.
537+50 Biotite schist with small pegmatite augen.
537+25 Highly injected biotite schist with some chlorite and sulphide
537+00 Highly injected biotite schist.
536+75 Highly injected biotite schist with sulphide.
536+50 Minutely injected biotite schist.
536+25 Floky biotite schist with small lenses
536+00 Quartz-orthoclase pegmatite
535+75 Pegmatite lenses in biotite schist
535+50 Pegmatite lens in chloritized biotite schist with sulphide.
535+26 Pegmatite bonds in coarse biotite schist.
535+00 Quartz biotite schist
N
535+00
Pegmatite lenses and streaks in massive schist, practically quartzite.
Slight north dip. Small pegmatite bonds and lenses in schist. Occurrence of small folds.
Foliation horizontal. Massive brown schist, very little pegmatite.
All massive schist with little pegmatite.
Foliation strike N74°W dip 16°N.
Floky quartz schist 50% pegmatite
Massive quartz schist interbedded with floky type. Few pegmatite lenses.
Foliation dip 20°E
Foliation strike N24°W dip 0°E.
Shallow syncline 50% pegmatite
30% pegmatite schist with pegmatite lenses
Schist is much chloritized
Foliation strike N66°E dip 13°W
Granitized schist, vertical foliation. Zone of vertical foliation between pegmatite mass. Vertical streaks in pegmatite.
80% pegmatite.
Some schist in pegmatite
75% pegmatite, large and small bodies.
Some schist inclusions.
25% pegmatite, banded injection.
Slight west dip.
Abundant pegmatite injection.
Pegmatite injection.
10% pegmatite.
Horizontal structure with slight local changes
Massive quartz biotite schist, bonded injection.
530+00
Slight shear
6' Shear zone, very little gauge.
1' Crush zone
Fault preceeding or associated with igneous activity. Movement interpreted as small with west side down. Brimfield type schist on both sides.
N46E
N46E
N46E
N31E
N59W
N46E
N36E
N31E
N6E
N41E
N43W
N21E
N76E
N6E
N74W
N31E
N11W
535+00 Quartz biotite schist.
534+75 Greenish quartz schist
534+50 Sheared pegmatite with graphite.
534+25 Biotite quartz schist
534+00 Quartz biotite schist with small pegmatite lenses.
533+75 Pegmatite lens in coarse slightly chloritized biotite schist
533+50 Slightly sheared pegmatite granite.
533+25 Pegmatite and fine biotite schist with sulphide.
533+00 Pegmatite lens in coarse slightly chloritized schist with sulphide
532+75 Bluish pegmatitic granite.
532+65 Coarse slightly altered muscovite schist.
532+50 Pegmatite granite
532+25 Pegmatitic granite with sericitic surfaces.
532+00 Greenish slightly sheared pegmatite
531+75 Pegmatite lens in chloritized schist. Graphite at margins of pegmatite
531+50 Pegmatite lens in coarse biotite schist
531+25 Biotite schist with pegmatite bands.
531+00 Bio. qtz. schist with pegmatite bands.
530+75 Biotite quartz schist.
530+60 Qtz. bio. schist with pegmatite bands
530+25 Quartz biotite schist.
530+00 Gray sericite quartz schist with pegmatite lens.
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86°33'W.
20 10 0 20 40 FT.

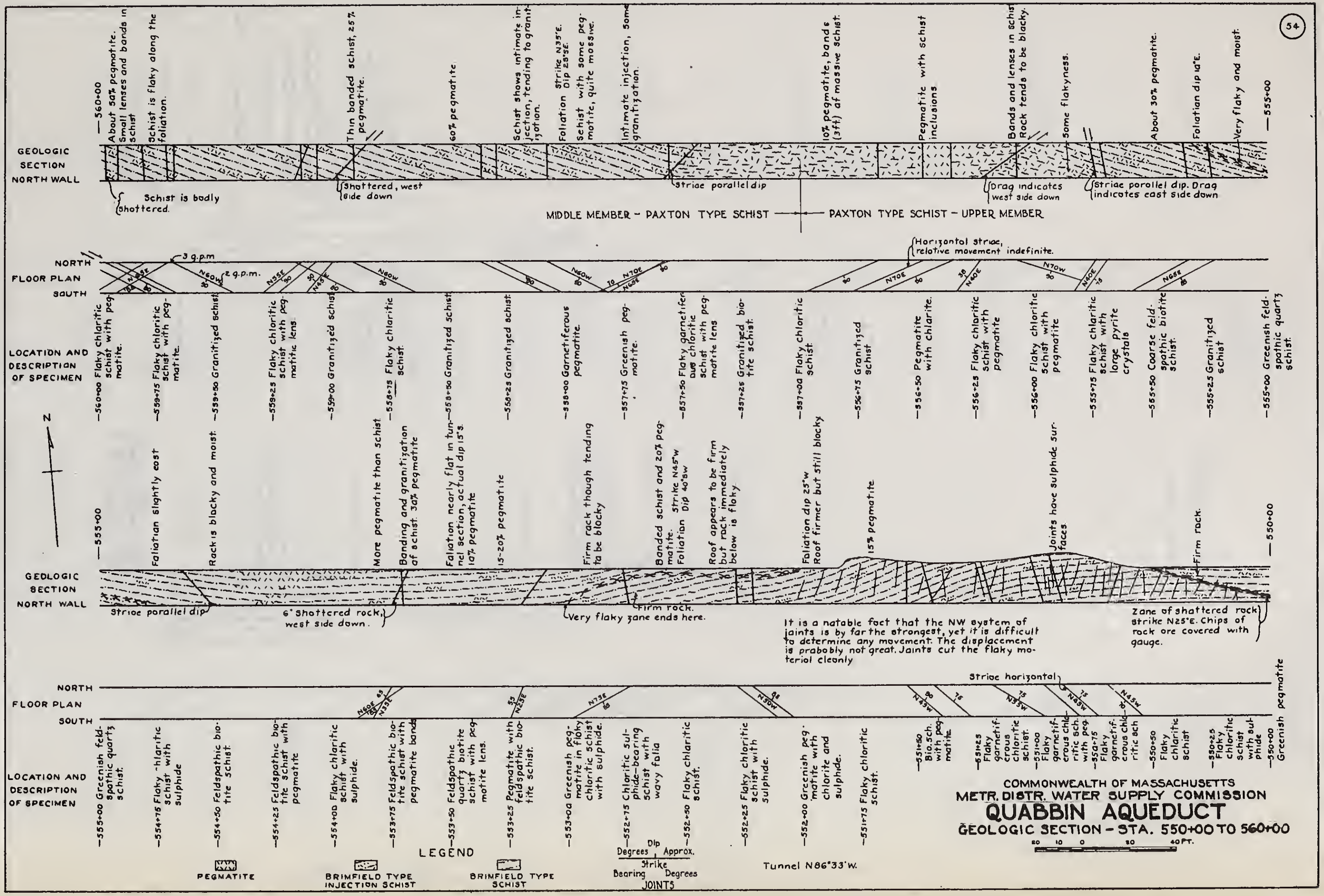
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 530+00 TO 540+00


(53)
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
— 550+00
South wall shows lenses of fine granite
Foliation on south wall indicates thrust from the west.
Very thin bands are quartzose
On south wall-carbonate filled fractures offsetting bands in massive schist, east side down. Strike N35°E, dip 90°
Foliation Strike N60°E. Dip 30°E (in section dip 15°E)
Banded injection
Foliation Strike N65°E. Dip 30°E (in section dip 10°E)
Contact dip 20°E
Massive pegmatite
Much shear and gouge.
Foliation Strike N5°W Dip 15°E
35% pegmatite.
— 545+00
Fine granite
Striae parallel dip, crushing and gouge.
Major fault preceding or associated with igneous activity Movement interpreted as west side down, displacement of approximately 200ft. Paxton type schist, middle member on east and upper member on west.
Horizontal movement, east side moved NE
N75E 85
N90E 60
N25E 45
N55W 80
—550+00 Greenish pegmatite.
—549+75 Partially granitized schist with fine pegmatite
—549+50 Chloritic quartz schist
—549+25 Feldspathic biotite schist with pegmatite.
—549+00 Feldspathic biotite schist.
—548+75 Biotite schist with quartz pegmatite band.
—548+50 Feldspathic biotite schist with quartz pegmatite bands
—548+25 Feldspathic biotite schist.
—548+00 Granitized biotite schist with pegmatite lenses
—547+75 Biotite schist with quartz pegmatite bands
—547+50 Coarse chloritic biotite schist with pegmatite lenses
—547+25 Garnetiferous pegmatite
—547+00 Chloritic biotite schist grading into pegmatite.
—546+75 Pegmatite with sericitic shear planes.
—546+50 Garnetiferous pegmatite.
—546+25 Garnetiferous pegmatite.
—546+00 Greenish gneissoid granite.
—545+75 Pegmatite with sericite.
—545+50 Feldspathic biotite schist.
—545+25 Greenish quartzite with garnet
—545+00 Granitized schist.
— 545+00
Banded injection.
Highly granitized schist
Banded schist with much pegmatite.
Slight east dip
Strongly injected.
Pegmatite lenses with banded injection schist.
Coarse pegmatite injection in coarse biotite schist. 75% pegmatite
Pegmatite lenses in banded somewhat granitized schist.
Almost entirely pegmatite with slight horizontal structure
Mostly pegmatite and granitized schist. 80% pegmatite.
Pegmatite lenses in schist and fine banded injection.
Foliation Strike N26°E. Dip 27°E
40% pegmatite
Banded Schist
Schist is much shattered and flaky. A foliation parallel to these joints and offsetting of pegmatite
Massive quartz biotite schist with pegmatite bands
Some crumpling.
Schist with much pegmatite banding and some granitization.
Massive schist showing some granitization and pegmatite.
Slight changes in foliation Banding and granitization of schist with much pegmatite.
— 540+00
Striae parallel dip. 6"-36" crush zone
Abundant sulphide
Striae dip 17°SE, west side SE. Good slickensides yet the joint does not appear to be continuous
striae almost horizontal
N61E 85
N36E 45
N54W
N41E 85
N68W 85
N41E 85
N16E 41 78
N51E
N31E 81
N54W 85
N86E 72
N46W 80
—545+00 Granitized schist
—544+75 Quartz biotite schist with pegmatite bands
—544+50 Biotite schist with pegmatite lenses
—544+25 Fine biotite quartz schist
—544+00 Biotite quartz schist with pegmatite
—543+75 Biotite quartz schist with pegmatite.
—543+50 Highly injected biotite schist
—543+25 Quartz biotite schist.
—543+00 Pegmatite
—542+75 Pegmatite.
—542+70 Crush rock with chlorite, sericite and sulphide
—542+50 Feldspathic biotite quartz schist
—542+25 Quartz biotite schist with pegmatite bands
—542+00 Greenish sheared pegmatite.
—541+75 Shattered slightly chloritized quartz biotite schist with pegmatite lenses.
—541+50 Qtz bio. schist with pegmatite
—541+25 Quartz biotite schist
—541+00 Banded biotite sericite schist.
—540+75 Qtz bio. schist with pegmatite.
—540+50 Quartz biotite schist.
—540+25 Fine gneissoid granite
—540+00 Injected biotite schist.
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
PAXTON TYPE INJECTION SCHIST
PAXTON TYPE SCHIST
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

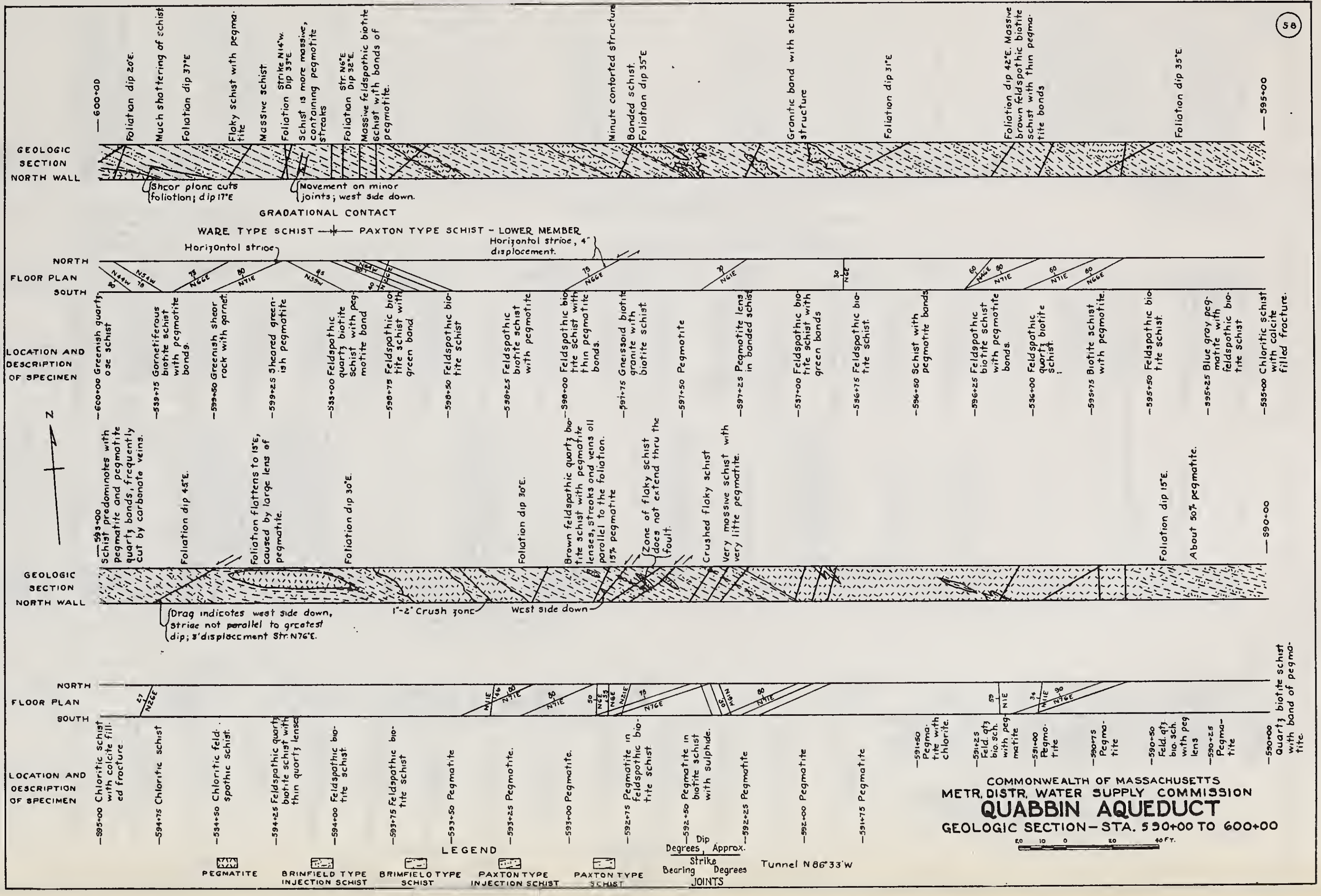
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 540+00 TO 550+00


GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
560+00
About 50% pegmatite. Small lenses and bands in schist
Schist is flaky along the foliation.
Schist is badly shattered.
Thin banded schist, 25% pegmatite.
Shattered, west side down
60% pegmatite
Schist shows intimate injection, tending to granitization.
Foliation Strike N35°E. Dip 25°SE.
Schist with some pegmatite, quite massive.
Intimate injection, Some granitization.
Striae parallel dip
10% pegmatite, bands (3ft.) of massive schist.
Pegmatite with schist inclusions
Bands and lenses in schist Rock tends to be blacky.
Drag indicates west side down
Some flakyness.
Striae parallel dip. Drag indicates east side down
About 30% pegmatite.
Foliation dip 10°E.
Very flaky and moist.
555+00
MIDDLE MEMBER – PAXTON TYPE SCHIST
PAXTON TYPE SCHIST – UPPER MEMBER
3 g.p.m
2 g.p.m.
Horizontal striae, relative movement indefinite.
N60W
N35E
N45E
N70E
N65E
N70W
N40E
N65E
560+00 Flaky chloritic schist with pegmatite.
559+75 Flaky chloritic schist with pegmatite.
559+50 Granitized schist
559+25 Flaky chloritic schist with pegmatitic lens.
559+00 Granitized schist
558+75 Flaky chloritic schist.
558+50 Granitized schist
558+25 Granitized schist
558+00 Garnetiferous pegmatite.
557+75 Greenish pegmatite.
557+50 Flaky garnetiferous chloritic schist with pegmatite lens
557+25 Granitized biotite schist.
557+00 Flaky chloritic schist
556+75 Granitized schist
556+50 Pegmatite with chlorite.
556+25 Flaky chloritic schist with pegmatite
556+00 Flaky chloritic schist with pegmatite
555+75 Flaky chloritic schist with large pyrite crystals
555+50 Coarse feldspathic biotite schist.
555+25 Granitized schist
555+00 Greenish feldspathic quartz schist.
555+00
Foliation slightly east
Rock is blacky and moist.
More pegmatite than schist
Banding and granitization of schist. 30% pegmatite
Foliation nearly flat in tunnel section, actual dip 15°S. 10% pegmatite
15-20% pegmatite
Firm rock though tending to be blocky
Banded schist and 20% pegmatite. Foliation Strike N45°W Dip 40°SW
Roof appears to be firm but rock immediately below is flaky.
Foliation dip 25°W Roof firmer but still blocky
15% pegmatite
Joints have sulphide surfaces
Firm rock.
550+00
Striae parallel dip
6" Shattered rock, west side down.
Very flaky zone ends here.
Firm rock.
It is a notable fact that the NW system of joints is by far the strongest, yet it is difficult to determine any movement. The displacement is probably not great. Joints cut the flaky material cleanly
Zone of shattered rock strike N25°E. Chips of rock are covered with gauge.
Striae horizontal
N60E
N35E
N25E
N75E
N30W
N45W
N35W
N45W
N45W
555+00 Greenish feldspathic quartz schist.
554+75 Flaky chloritic schist with sulphide
554+50 Feldspathic biotite schist.
554+25 Feldspathic biotite schist with pegmatite
554+00 Flaky chloritic schist with sulphide.
553+75 Feldspathic biotite schist with pegmatite bands
553+50 Feldspathic quartz biotite schist with pegmatite lens.
553+25 Pegmatite with feldspathic biotite schist.
553+00 Greenish pegmatite in flaky chloritic schist with sulphide.
552+75 Chloritic sulphide-bearing schist with wavy folia
552+50 Flaky chloritic schist.
552+25 Flaky chloritic schist with sulphide.
552+00 Greenish pegmatite with chlorite and sulphide.
551+75 Flaky chloritic schist.
551+50 Bio. sch. with pegmatite
551+25 Flaky garnetiferous chloritic schist.
551+00 Flaky garnetiferous chloritic sch. with peg.
550+75 Flaky garnetiferous chloritic sch
550+50 Flaky chloritic schist
550+25 Flaky chloritic schist with sulphide
550+00 Greenish pegmatite
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

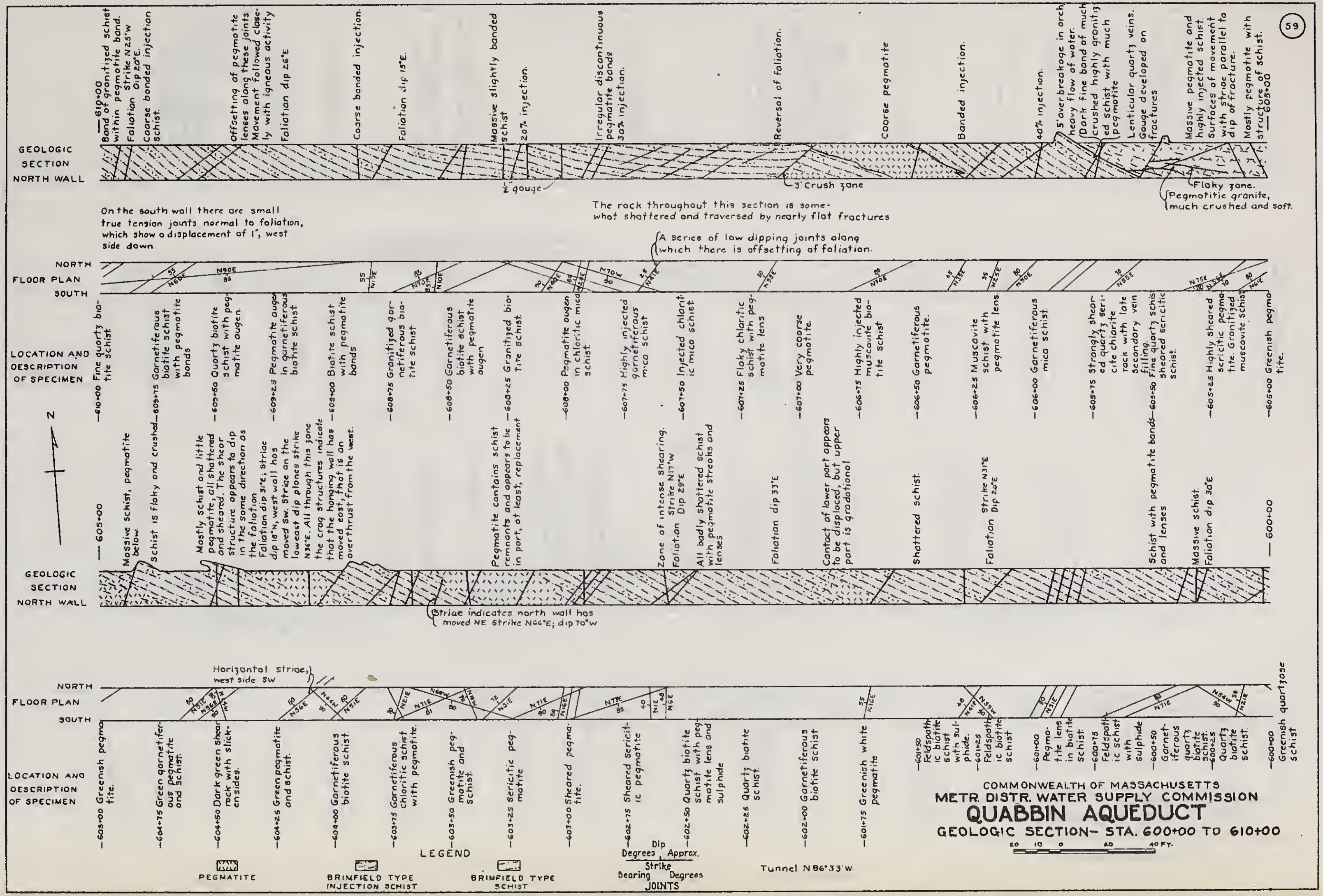
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 550+00 TO 560+00


58
GEOLOGIC SECTION NORTH WALL
— 600+00
Foliation dip 20°E.
Much shattering of schist
Foliation dip 37°E
Flaky schist with pegmatite
Massive schist
Foliation Strike N14°W. Dip 33°E
Schist is more massive, containing pegmatite streaks
Foliation Str. N6°E Dip 32°E.
Massive feldspathic biotite schist with bands of pegmatite.
Minute contorted structure
Banded schist. Foliation dip 35°E
Granitic band with schist structure
Foliation dip 31°E
Foliation dip 42°E. Massive brown feldspathic biotite schist with thin pegmatite bands
Foliation dip 35°E
— 595+00
Shear plane cuts foliation; dip 17°E
Movement on minor joints; west side down.
GRADATIONAL CONTACT
WARE TYPE SCHIST —+— PAXTON TYPE SCHIST - LOWER MEMBER
Horizontal striae
Horizontal striae, 4" displacement.
NORTH
FLOOR PLAN
SOUTH
N44W 80
N54W 78
75 N66E
80 N71E
85 N59W
80 N64W
40 N26E
75 N66E
70 N61E
30 N6E
60 N46E
80 N71E
60 N71E
80 N66E
LOCATION AND DESCRIPTION OF SPECIMEN
—600+00 Greenish quartzose schist
—599+75 Garnetiferous biotite schist with pegmatite bands.
—599+50 Greenish shear rock with garnet.
—599+25 Sheared greenish pegmatite
—599+00 Feldspathic quartz biotite schist with pegmatite band
—598+75 Feldspathic biotite schist with green band
—598+50 Feldspathic biotite schist
—598+25 Feldspathic biotite schist with pegmatite
—598+00 Feldspathic biotite schist with thin pegmatite bands.
—597+75 Gneissoid biotite granite with biotite schist.
—597+50 Pegmatite
—597+25 Pegmatite lens in banded schist
—597+00 Feldspathic biotite schist with green bands
—596+75 Feldspathic biotite schist.
—596+50 Schist with pegmatite bands
—596+25 Feldspathic biotite schist with pegmatite bands.
—596+00 Feldspathic quartz biotite schist.
—595+75 Biotite schist with pegmatite.
—595+50 Feldspathic biotite schist.
—595+25 Blue gray pegmatite with feldspathic biotite schist
—595+00 Chloritic schist with calcite filled fracture.
N
GEOLOGIC SECTION NORTH WALL
—595+00
Schist predominates with pegmatite and pegmatite quartz bands, frequently cut by carbonate veins.
Foliation dip 45°E.
Foliation flattens to 15°E, caused by large lens of pegmatite.
Foliation dip 30°E.
Foliation dip 30°E.
Brown feldspathic quartz biotite schist with pegmatite lenses, streaks and veins all parallel to the foliation. 15% pegmatite
Zone of flaky schist does not extend thru the fault.
Crushed flaky schist
Very massive schist with very little pegmatite.
Foliation dip 15°E.
About 50% pegmatite.
— 590+00
Drag indicates west side down, striae not parallel to greatest dip; 3' displacement Str. N76°E.
1"-2" Crush zone
West side down
NORTH
FLOOR PLAN
SOUTH
47 N26E
N1E 46
80 N71E
80 N71E
50 N6E
35 N6E
N21E
75 N76E
50 N61W
80 N71E
59 N1E
34 N1E
90 N76E
LOCATION AND DESCRIPTION OF SPECIMEN
—595+00 Chloritic schist with calcite filled fracture.
—594+75 Chloritic schist
—594+50 Chloritic feldspathic schist.
—594+25 Feldspathic quartz biotite schist with thin quartz lenses
—594+00 Feldspathic biotite schist
—593+75 Feldspathic biotite schist
—593+50 Pegmatite
—593+25 Pegmatite.
—593+00 Pegmatite.
—592+75 Pegmatite in feldspathic biotite schist
—592+50 Pegmatite in biotite schist with sulphide.
—592+25 Pegmatite
—592+00 Pegmatite
—591+75 Pegmatite
—591+50 Pegmatite with chlorite.
—591+25 Feld. qtz bio. sch. with pegmatite
—591+00 Pegmatite
—590+75 Pegmatite
—590+50 Feld. qtz bio. sch. with peg lens
—590+25 Pegmatite
—590+00 Quartz biotite schist with band of pegmatite.
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
PAXTON TYPE INJECTION SCHIST
PAXTON TYPE SCHIST
Dip Degrees, Approx. Strike Bearing Degrees
JOINTS
Tunnel N 86°33'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 590+00 TO 600+00

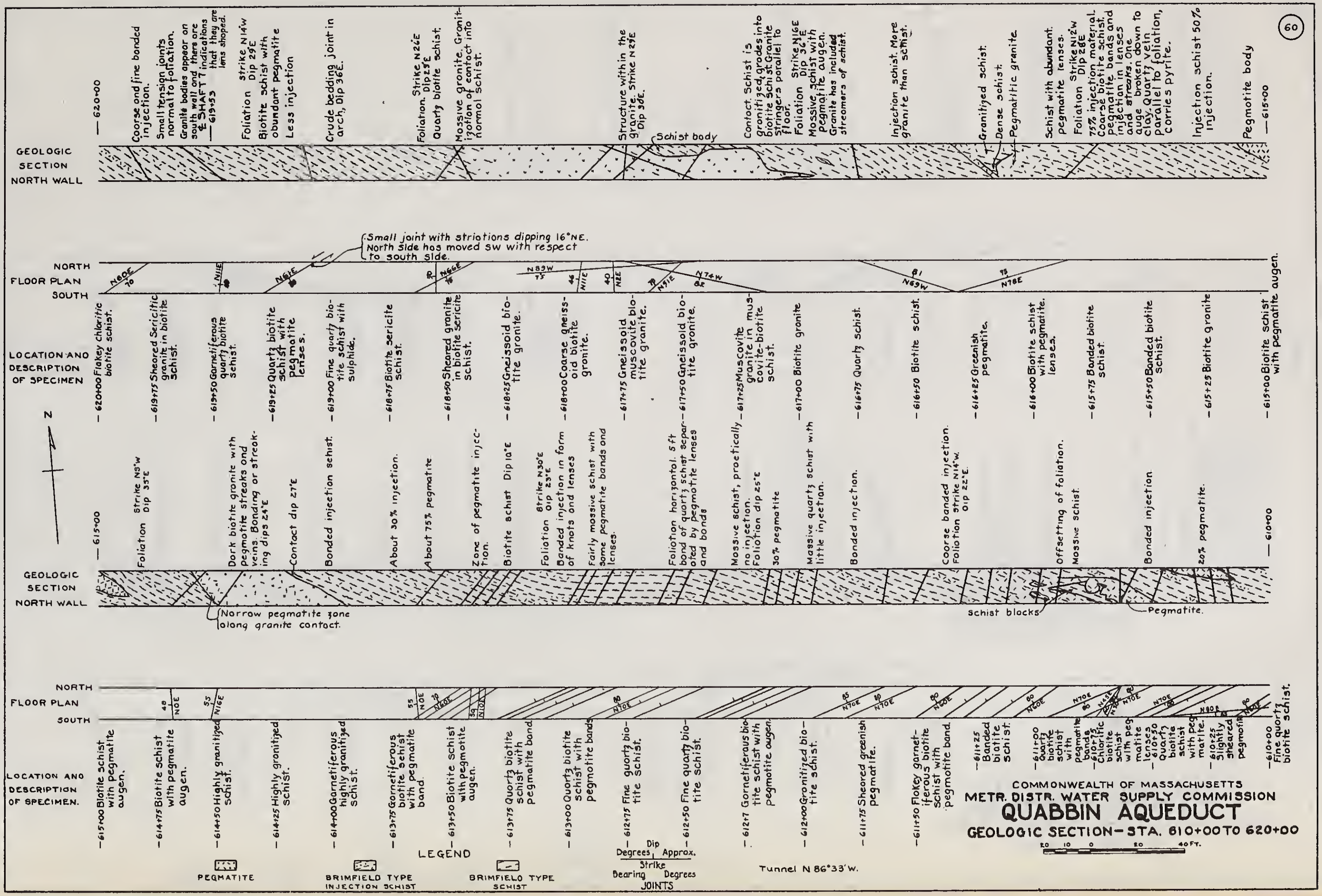


GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
610+00
Band of granitized schist within pegmatite band.
Foliation Strike N25°W Dip 20°E.
Coarse banded injection schist.
Offsetting of pegmatite lenses along these joints Movement followed closely with igneous activity
Foliation dip 26°E
Coarse banded injection.
Foliation dip 15°E.
Massive slightly banded schist
20% injection.
½" gouge
Irregular discontinuous pegmatite bands 30% injection.
3' Crush zone
Reversal of foliation.
Coarse pegmatite
Banded injection.
40% injection.
5' overbreakage in arch heavy flow of water.
Dark fine band of much crushed highly granitized schist with much pegmatite
Lenticular quartz veins. Gauge developed on fractures
Flaky zone.
Pegmatitic granite, much crushed and soft.
Massive pegmatite and highly injected schist. Surfaces of movement with striae parallel to dip of fracture.
Mostly pegmatite with structure of schist.
605+00
On the south wall there are small true tension joints normal to foliation, which show a displacement of 1", west side down.
The rock throughout this section is somewhat shattered and traversed by nearly flat fractures
A series of low dipping joints along which there is offsetting of foliation.
610+00 Fine quartz biotite schist
609+75 Garnetiferous biotite schist with pegmatite bands
609+50 Quartz biotite schist with pegmatite augen.
609+25 Pegmatite augen in garnetiferous biotite schist
609+00 Biotite schist with pegmatite bands
608+75 Granitized garnetiferous biotite schist
608+50 Garnetiferous biotite schist with pegmatite augen
608+25 Granitized biotite schist.
608+00 Pegmatite augen in chloritic mica schist
607+75 Highly injected garnetiferous mica schist
607+50 Injected chloritic mica schist
607+25 Flaky chloritic schist with pegmatite lens
607+00 Very coarse pegmatite.
606+75 Highly injected muscovite biotite schist
606+50 Garnetiferous pegmatite.
606+25 Muscovite schist with pegmatite lens
606+00 Garnetiferous mica schist.
605+75 Strongly sheared quartz sericite chlorite rock with late secondary vein filling.
605+50 Fine quartz schist sheared sericitic schist.
605+25 Highly sheared sericitic pegmatite. Granitized muscovite schist
605+00 Greenish pegmatite.
605+00
Massive schist, pegmatite below.
Schist is flaky and crushed
Mostly schist and little pegmatite, all shattered and sheared. The shear structure appears to dip in the same direction as the foliation Foliation dip 31°E; striae dip 18°N, west wall has moved SW. Striae on the lowest dip planes strike N36°E. All through this zone the crag structures indicate that the hanging wall has moved east, that is an overthrust from the west.
Pegmatite contains schist remnants and appears to be in part, at least, replacement
Zone of intense shearing. Foliation Strike N17°W Dip 29°E
All badly shattered schist with pegmatite streaks and lenses
Foliation dip 33°E
Contact of lower part appears to be displaced, but upper part is gradational
Shattered schist.
Foliation Strike N31°E Dip 20°E
Schist with pegmatite bands and lenses
Massive schist. Foliation dip 30°E
600+00
Striae indicates north wall has moved NE Strike N66°E; dip 70°W
Horizontal striae, west side SW
605+00 Greenish pegmatite.
604+75 Green garnetiferous pegmatite and schist.
604+50 Dark green shear rock with slickensides.
604+25 Green pegmatite and schist.
604+00 Garnetiferous biotite schist.
603+75 Garnetiferous chloritic schist with pegmatite.
603+50 Greenish pegmatite and schist.
603+25 Sericitic pegmatite
603+00 Sheared pegmatite.
602+75 Sheared sericitic pegmatite
602+50 Quartz biotite schist with pegmatite lens and sulphide
602+25 Quartz biotite schist.
602+00 Garnetiferous biotite schist
601+75 Greenish white pegmatite
601+50 Feldspathic biotite schist with sulphide.
601+25 Feldspathic biotite schist
601+00 Pegmatite lens in biotite schist.
600+75 Feldspathic schist with sulphide
600+50 Garnetiferous quartz biotite schist.
600+25 Quartz biotite schist.
600+00 Greenish quartzose schist
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

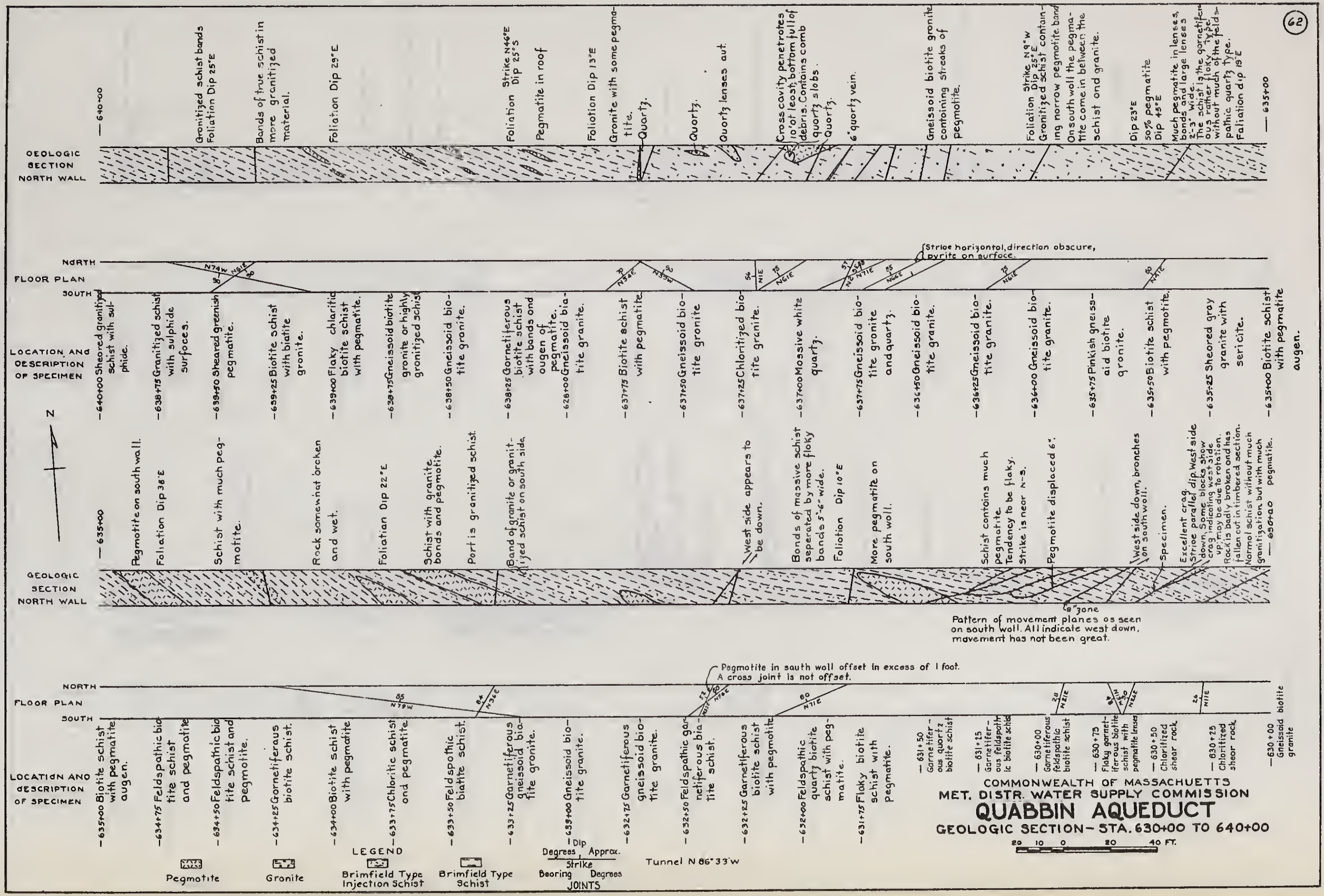
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION– STA. 600+00 TO 610+00


GEOLOGIC SECTION NORTH WALL
620+00
Coarse and fine banded injection.
Small tension joints normal to foliation.
Granite bodies appear on south wall and there are indications that they are lens shaped.
℄ SHAFT 7
619+53
Foliation Strike N14W Dip 29E
Biotite schist with abundant pegmatite
Less injection
Crude bedding joint in arch, Dip 36E.
Foliation. Strike N26E Dip 25E
Quartz biotite schist.
Massive granite. Granitization of contact into normal schist.
Structure within the granite. Strike N29E Dip 36E.
Schist body
Contact. Schist is granitized, grades into biotite schist. Granite stringers parallel to floor.
Foliation Strike N16E Dip 36E
Massive schist with pegmatite augen.
Granite has included streamers of schist.
Injection schist. More granite than schist.
Granitized schist.
Dense schist.
Pegmatitic granite.
Schist with abundant pegmatite lenses.
Foliation Strike N12W Dip 28E
75% injection material. Coarse biotite schist. pegmatite bands and injection in lenses and streaks. One auge broken down to clay. Quartz vein parallel to foliation, carries pyrite.
Injection schist 50% injection.
Pegmatite body
615+00
Small joint with striations dipping 16°NE. North side has moved SW with respect to south side.
NORTH
FLOOR PLAN
SOUTH
N60E 70
N11E
N61E
N66E 76
R
N83W 75
46 N11E
40 N2E
N51E
N74W 82
81 N69W
73 N78E
LOCATION AND DESCRIPTION OF SPECIMEN
620+00 Flakey chloritic biotite schist.
619+75 Sheared Sericitic granite in biotite schist.
619+50 Garnetiferous quartz biotite schist.
619+25 Quartz biotite schist with pegmatite lenses.
619+00 Fine quartz biotite schist with sulphide.
618+75 Biotite sericite schist.
618+50 Sheared granite in biotite sericite schist.
618+25 Gneissoid biotite granite.
618+00 Coarse gneissoid biotite granite.
617+75 Gneissoid muscovite biotite granite.
617+50 Gneissoid biotite granite.
617+25 Muscovite granite in muscovite-biotite schist.
617+00 Biotite granite
616+75 Quartz schist.
616+50 Biotite schist.
616+25 Greenish pegmatite.
616+00 Biotite schist with pegmatite lenses.
615+75 Banded biotite schist.
615+50 Banded biotite schist.
615+25 Biotite granite
615+00 Biotite schist with pegmatite augen.
N
GEOLOGIC SECTION NORTH WALL
615+00
Foliation Strike N5°W Dip 35°E
Dark biotite granite with pegmatite streaks and veins. Banding or streaking dips 24°E
Contact dip 27°E
Banded injection schist.
About 30% injection.
About 75% pegmatite
Zone of pegmatite injection.
Biotite schist Dip 10°E
Foliation Strike N30°E Dip 23°E
Banded injection in form of knots and lenses
Fairly massive schist with some pegmatite bands and lenses.
Foliation horizontal. 5 ft band of quartz schist separated by pegmatite lenses and bands
Massive schist, practically no injection. Foliation dip 25°E
30% pegmatite
Massive quartz schist with little injection.
Banded injection.
Coarse banded injection. Foliation strike N14°W. Dip 22°E.
Offsetting of foliation.
Massive schist.
Banded injection.
20% pegmatite.
610+00
Narrow pegmatite zone along granite contact.
Schist blocks
Pegmatite.
NORTH
FLOOR PLAN
SOUTH
48 N0E
55 N16E
55 N0E
70 N60E
39 N10E
80 N70E
85 N70E
80 N70E
80 N60E
80 N60E
N70E 80
N45E
N70E
80 N70E
N70E 80
N80E
80 N60E
LOCATION AND DESCRIPTION OF SPECIMEN.
615+00 Biotite schist with pegmatite augen.
614+75 Biotite schist with pegmatite augen.
614+50 Highly granitized schist.
614+25 Highly granitized schist.
614+00 Garnetiferous highly granitized schist.
613+75 Garnetiferous biotite schist with pegmatite band.
613+50 Biotite schist with pegmatite augen.
613+75 Quartz biotite schist with pegmatite band
613+00 Quartz biotite schist with pegmatite bands
612+75 Fine quartz biotite schist.
612+50 Fine quartz biotite schist.
612+7 Garnetiferous biotite schist with pegmatite augen.
612+00 Granitized biotite schist.
611+75 Sheared greenish pegmatite.
611+50 Flakey garnetiferous biotite schist with pegmatite band.
611+25 Banded biotite schist.
611+00 Quartz biotite schist with pegmatite bands
610+75 Chloritic biotite schist with pegmatite lenses
610+50 Quartz biotite schist with pegmatite.
610+25 Slightly sheared pegmatite
610+00 Fine quartz biotite schist.
LEGEND
PEGMATITE
BRIMFIELD TYPE INJECTION SCHIST
BRIMFIELD TYPE SCHIST
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86°33' W.
20 10 0 20 40 FT.

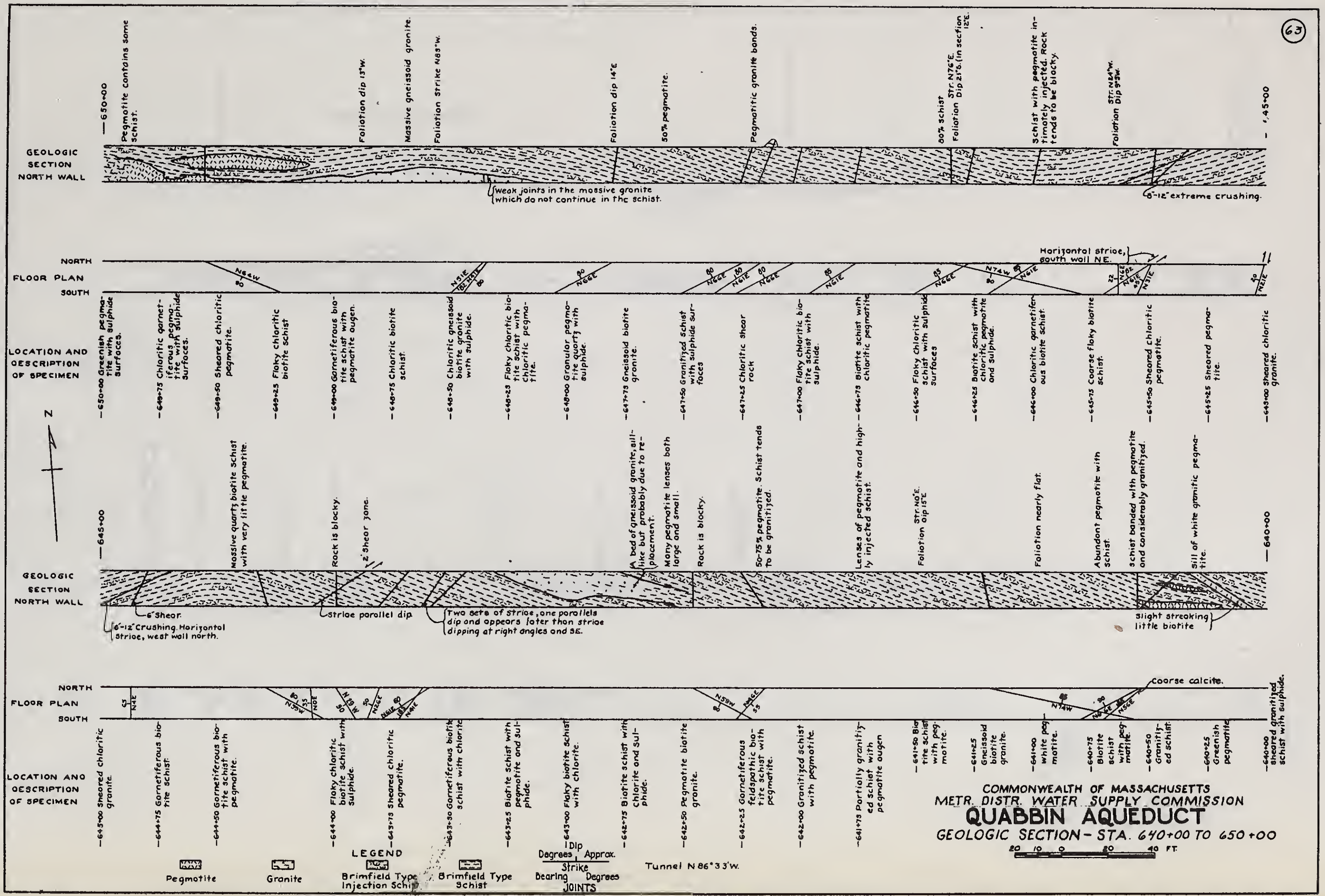
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 610+00 TO 620+00


62
GEOLOGIC SECTION NORTH WALL
— 640+00
Granitized schist bands Foliation Dip 25°E
Bands of true schist in more granitized material.
Foliation Dip 29°E
Foliation Strike N46°E Dip 25°S
Pegmatite in roof
Foliation Dip 13°E
Granite with some pegmatite.
Quartz.
Quartz.
Quartz lenses out.
Cross cavity penetrates 10' at least; bottom full of debris. Contains comb quartz slabs.
Quartz.
6" quartz vein.
Gneissoid biotite granite containing streaks of pegmatite.
Foliation Strike N9°W Dip 25°E
Granitized schist containing narrow pegmatite band
On south wall the pegmatite come in between the schist and granite.
Dip 23°E
50% pegmatite Dip 45°E
Much pegmatite in lenses, bands and large lenses 2'-3' wide.
The schist is the garnetiferous rather flaky type without much of the feldspathic quartz type.
Foliation dip 13°E
— 635+00
NORTH
FLOOR PLAN
SOUTH
N74W 8
N61E 30
70 N54E
N35W 80
56 N1E
75 N61E
57 N2 35E 40 N71E
85 N66E
Striae horizontal, direction obscure, pyrite on surface.
75 N61E
60 N41E
LOCATION AND DESCRIPTION OF SPECIMEN
-640+00 Sheared granitized schist with sulphide.
-638+75 Granitized schist with sulphide surfaces.
-639+50 Sheared greenish pegmatite.
-639+25 Biotite schist with biotite granite.
-639+00 Flaky chloritic biotite schist with pegmatite.
-638+75 Gneissoid biotite granite or highly granitized schist
-638+50 Gneissoid biotite granite.
-638+25 Garnetiferous biotite schist with bands and augen of pegmatite.
-628+00 Gneissoid biotite granite.
-637+75 Biotite schist with pegmatite.
-637+50 Gneissoid biotite granite
-637+25 Chloritized biotite granite.
-637+00 Massive white quartz.
-637+75 Gneissoid biotite granite and quartz.
-636+50 Gneissoid biotite granite.
-636+25 Gneissoid biotite granite.
-636+00 Gneissoid biotite granite.
-635+75 Pinkish gneissoid biotite granite.
-635+50 Biotite schist with pegmatite.
-635+25 Sheared gray granite with sericite.
-635+00 Biotite schist with pegmatite augen.
N
GEOLOGIC SECTION NORTH WALL
— 635+00
Pegmatite on south wall.
Foliation Dip 38°E
Schist with much pegmatite.
Rock somewhat broken and wet.
Foliation Dip 22°E
Schist with granite bands and pegmatite.
Part is granitized schist.
Band of granite or granitized schist on south side.
West side appears to be down.
Bands of massive schist separated by more flaky bands 5'-6" wide.
Foliation Dip 10°E
More pegmatite on south wall.
Schist contains much pegmatite.
Tendency to be flaky.
Strike is near N-S.
Pegmatite displaced 6".
West side down, branches on south wall.
Specimen.
Excellent crag.
Striae parallel dip. West side down. Some blocks show crag indicating west side up; may be due to rotation.
Rock is badly broken and has fallen out in timbered section.
Normal schist without much granitization but with much pegmatite.
— 630+00
8" zone
Pattern of movement planes as seen on south wall. All indicate west down, movement has not been great.
Pegmatite in south wall offset in excess of 1 foot. A cross joint is not offset.
NORTH
FLOOR PLAN
SOUTH
85 N79W
84 N36E
52 N33E 60 N56E
60 N71E
28 N21E
84 N51N 30 N26E
26 N11E
LOCATION AND DESCRIPTION OF SPECIMEN
-635+00 Biotite schist with pegmatite augen.
-634+75 Feldspathic biotite schist and pegmatite
-634+50 Feldspathic biotite schist and pegmatite.
-634+25 Garnetiferous biotite schist.
-634+00 Biotite schist with pegmatite
-633+75 Chloritic schist and pegmatite
-633+50 Feldspathic biotite schist.
-633+25 Garnetiferous gneissoid biotite granite.
-633+00 Gneissoid biotite granite.
-632+75 Garnetiferous gneissoid biotite granite.
-632+50 Feldspathic garnetiferous biotite schist.
-632+25 Garnetiferous biotite schist with pegmatite
-632+00 Feldspathic quartz biotite schist with pegmatite.
-631+75 Flaky biotite schist with pegmatite.
— 631+50 Garnetiferous quartz biotite schist
— 631+25 Garnetiferous feldspathic biotite schist
— 630+00 Garnetiferous feldspathic biotite schist
— 630+75 Flaky garnetiferous biotite schist with pegmatite lenses
— 630+50 Chloritized shear rock
— 630+25 Chloritized shear rock
— 630+00 Gneissoid biotite granite
LEGEND
Pegmatite
Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 86°33'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUETTS
MET. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 630+00 TO 640+00

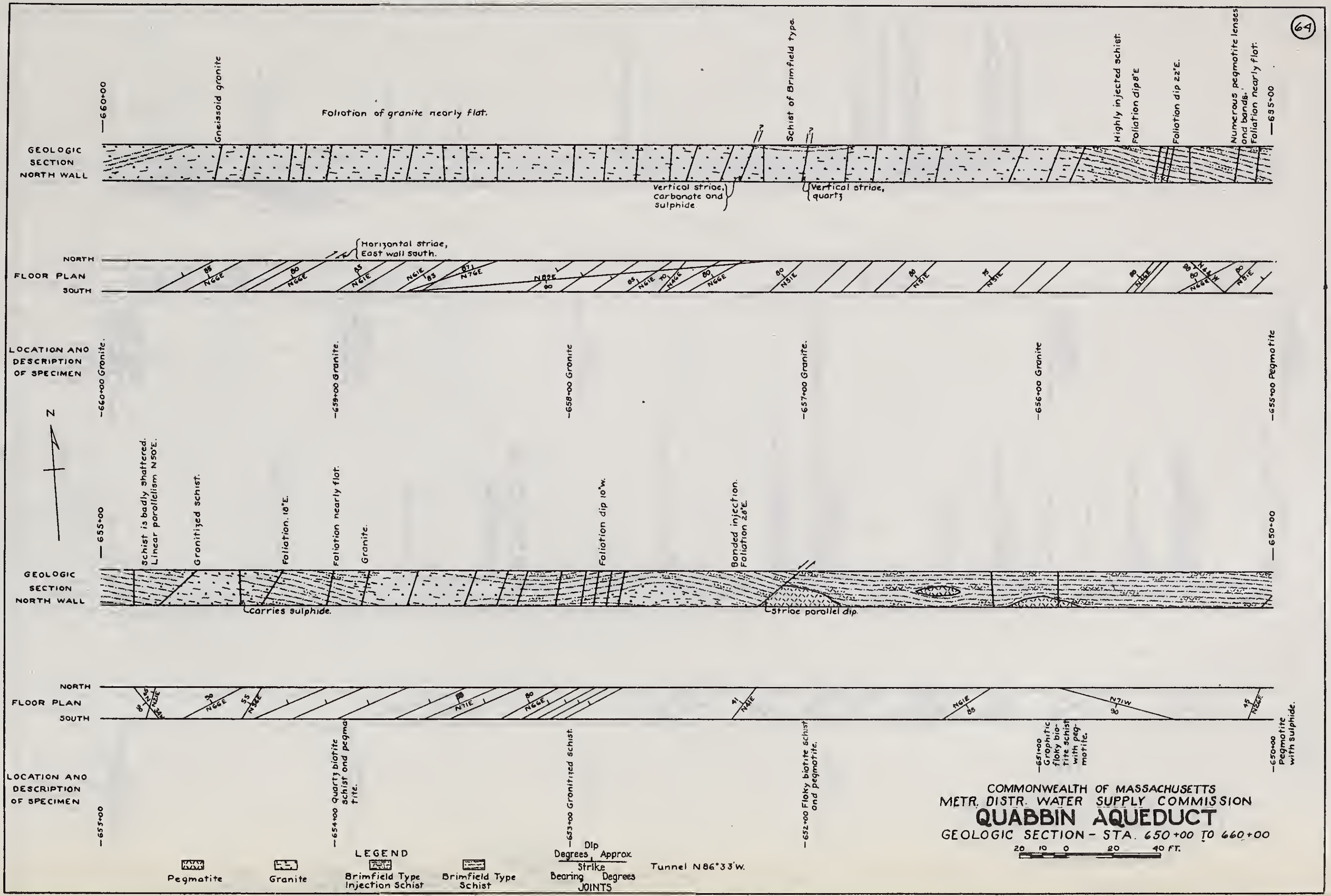


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

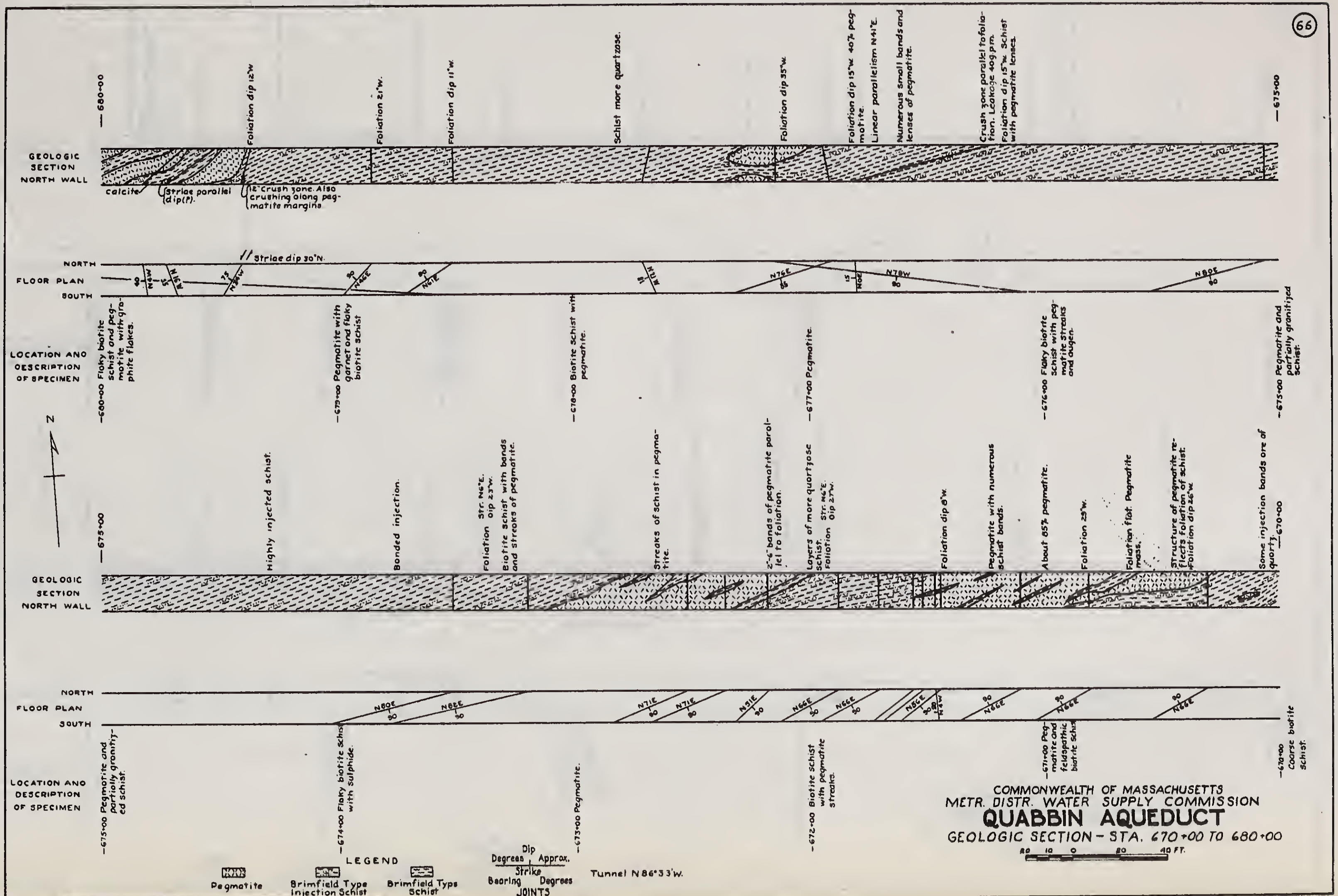
QUABBIN AQUEDUCT

GEOLOGIC SECTION - STA. 640+00 TO 650+00

GEOLOGIC SECTION NORTH WALL
650+00
Pegmatite contains some schist.
Foliation dip 13°W.
Massive gneissoid granite.
Foliation strike N83°W.
Weak joints in the massive granite which do not continue in the schist.
Foliation dip 14°E
50% pegmatite.
Pegmatitic granite bands.
80% schist
Foliation Str. N76°E. Dip 21°S. (In section 12°E.
Schist with pegmatite intimately injected. Rock tends to be blocky.
Foliation Str. N24°W. Dip 9°W.
6"-12" extreme crushing.
645+00
NORTH
FLOOR PLAN
SOUTH
Horizontal striae, south wall NE.
N64W
N31E
N31E
N66E
N61E
N74W
N6E
N31E
N21E
LOCATION AND DESCRIPTION OF SPECIMEN
650+00 Greenish pegmatite with sulphide surfaces.
649+75 Chloritic garnetiferous pegmatite with sulphide surfaces.
649+50 Sheared chloritic pegmatite.
649+25 Flaky chloritic biotite schist
649+00 Garnetiferous biotite schist with pegmatite augen.
648+75 Chloritic biotite schist.
648+50 Chloritic gneissoid biotite granite with sulphide.
648+25 Flaky chloritic biotite schist with chloritic pegmatite.
648+00 Granular pegmatite quartz with sulphide.
647+75 Gneissoid biotite granite.
647+50 Granitized schist with sulphide surfaces
647+25 Chloritic shear rock
647+00 Flaky chloritic biotite schist with sulphide.
646+75 Biotite schist with chloritic pegmatite
646+50 Flaky chloritic schist with sulphide surfaces
646+25 Biotite schist with chloritic pegmatite and sulphide.
646+00 Chloritic garnetiferous biotite schist.
645+75 Coarse flaky biotite schist.
645+50 Sheared chloritic pegmatite.
645+25 Sheared pegmatite.
645+00 Sheared chloritic granite.
N
645+00
Massive quartz biotite schist with very little pegmatite.
Rock is blocky.
2" Shear zone.
A bed of gneissoid granite, sill-like but probably due to replacement.
Many pegmatite lenses both large and small.
Rock is blocky.
50-75% pegmatite. Schist tends to be granitized.
Lenses of pegmatite and highly injected schist.
Foliation Str. N0°E. dip 15°E
Foliation nearly flat.
Abundant pegmatite with schist.
Schist banded with pegmatite and considerably granitized.
Sill of white granitic pegmatite.
640+00
GEOLOGIC SECTION NORTH WALL
6" Shear.
6"-12" Crushing. Horizontal striae, west wall north.
Striae parallel dip.
Two sets of striae, one parallels dip and appears later than striae dipping at right angles and SE.
Slight streaking little biotite
NORTH
FLOOR PLAN
SOUTH
N4E
N35W
N0E
N19W
N26E
N61E
N41E
N59W
N56E
N74W
N56E
Coarse calcite.
LOCATION AND DESCRIPTION OF SPECIMEN
645+00 Sheared chloritic granite.
644+75 Garnetiferous biotite schist.
644+50 Garnetiferous biotite schist with pegmatite.
644+00 Flaky chloritic biotite schist with sulphide.
643+75 Sheared chloritic pegmatite.
643+50 Garnetiferous biotite schist with chlorite
643+25 Biotite schist with pegmatite and sulphide.
643+00 Flaky biotite schist with chlorite.
642+75 Biotite schist with chlorite and sulphide.
642+50 Pegmatite biotite granite.
642+25 Garnetiferous feldspathic biotite schist with pegmatite.
642+00 Granitized schist with pegmatite.
641+75 Partially granitized schist with pegmatite augen
641+50 Biotite schist with pegmatite.
641+25 Gneissoid biotite granite.
641+00 White pegmatite.
640+75 Biotite schist with pegmatite.
640+50 Granitized schist.
640+25 Greenish pegmatite
640+00 Sheared granitized schist with sulphide.
LEGEND
Pegmatite
Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx. Strike Bearing Degrees JOINTS
Tunnel N 86°33'W.
20 10 0 20 40 FT.



COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION - STA. 650+00 TO 660+00



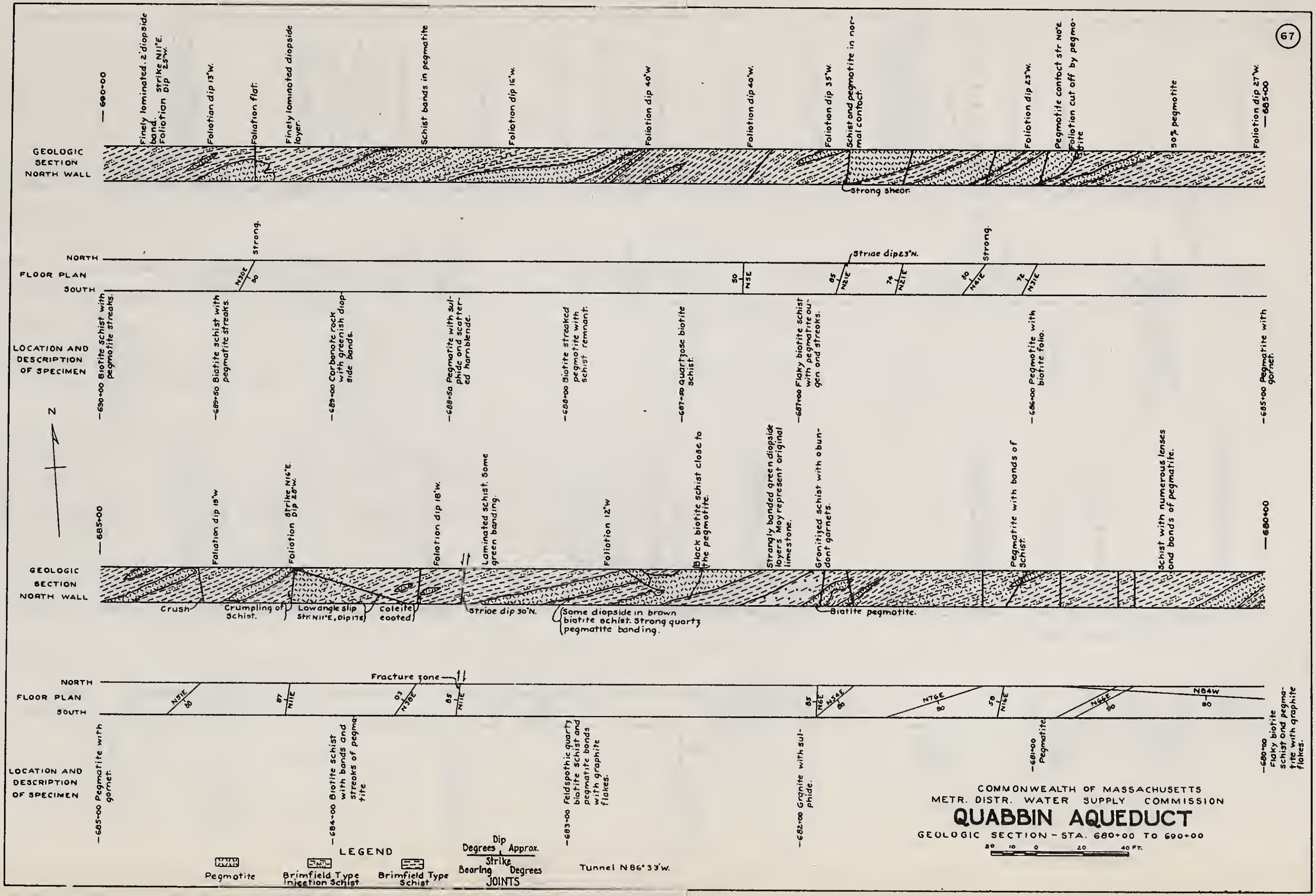
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 670+00 TO 680+00

66
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
680+00
675+00
670+00
Foliation dip 12°W
Foliation 21°W.
Foliation dip 11°W.
Schist more quartzose.
Foliation dip 35°W.
Foliation dip 15°W. 40% pegmatite.
Linear parallelism N41°E.
Numerous small bands and lenses of pegmatite.
Crush zone parallel to foliation. Leakage 40g.p.m.
Foliation dip 15°W. Schist with pegmatite lenses.
calcite
Striae parallel dip(?).
12" Crush zone. Also crushing along pegmatite margins
// Striae dip 30°N.
N4W
N31W
N34W
N46E
N61E
N11W
N76E
N0E
N78W
N80E
-680+00 Flaky biotite schist and pegmatite with graphite flakes.
-679+00 Pegmatite with garnet and flaky biotite schist
-678+00 Biotite schist with pegmatite.
-677+00 Pegmatite.
-676+00 Flaky biotite schist with pegmatite streaks and augen.
-675+00 Pegmatite and partially granitized schist.
N
Highly injected schist.
Banded injection.
Foliation Str. N6°E. Dip 23°W.
Biotite schist with bands and streaks of pegmatite.
Streaks of schist in pegmatite.
2"-6" bands of pegmatite parallel to foliation.
Layers of more quartzose schist. Foliation Str. N6°E. Dip 27°W.
Foliation dip 8°W.
Pegmatite with numerous schist bands.
About 85% pegmatite.
Foliation 25°W.
Foliation flat. Pegmatite mass.
Structure of pegmatite reflects foliation of schist. Foliation dip 26°W.
Some injection bands are of quartz.
N80E
N82E
N71E
N51E
N66E
N86E
N4W
-675+00 Pegmatite and partially granitized schist.
-674+00 Flaky biotite schist with sulphide.
-673+00 Pegmatite.
-672+00 Biotite schist with pegmatite streaks.
-671+00 Pegmatite and feldspathic biotite schist
-670+00 Coarse biotite schist.
LEGEND
Pegmatite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx. Strike Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

(67)

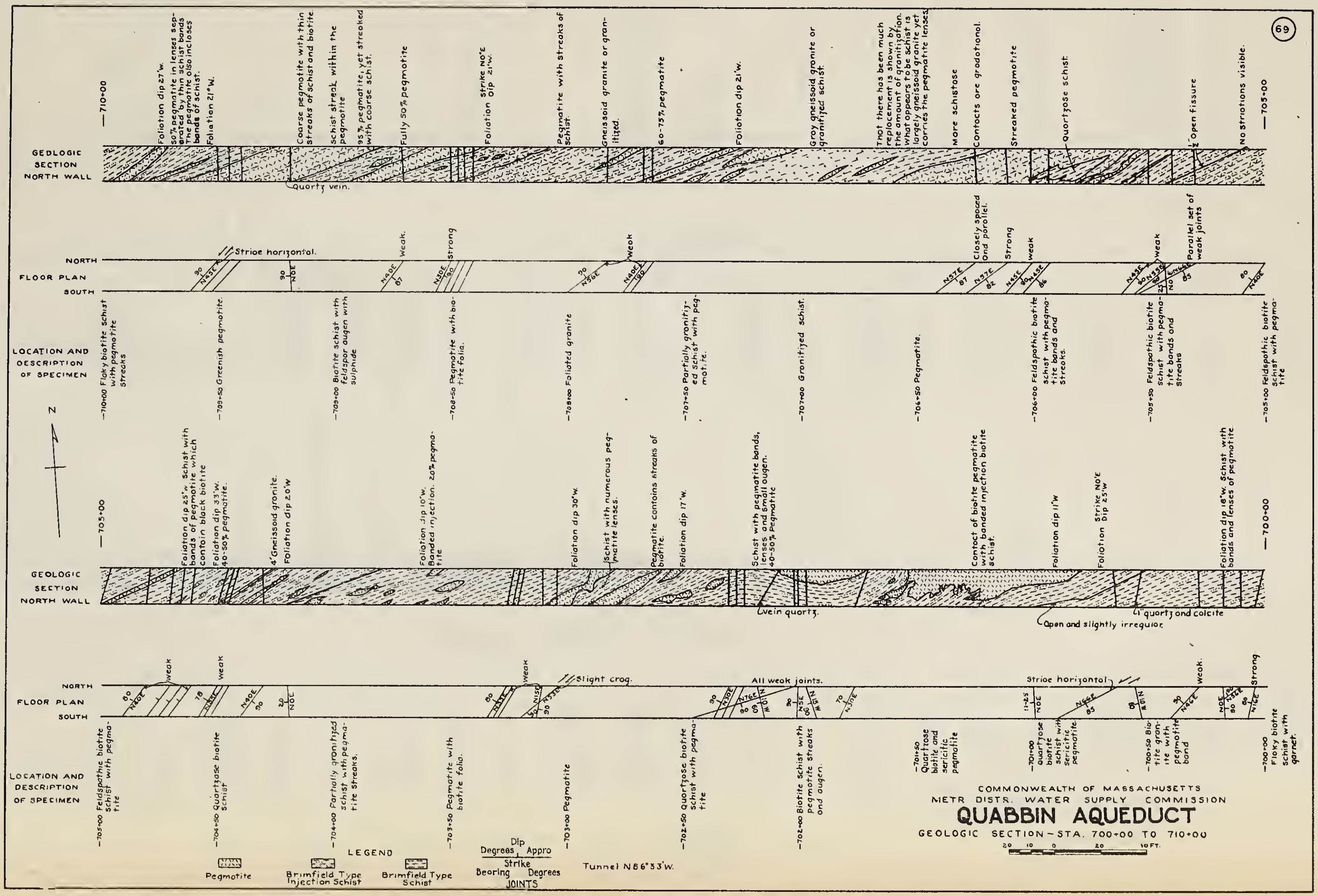


GEOLOGIC SECTION NORTH WALL
— 690+00
Finely laminated. 2' diopside band. Foliation strike N11°E. Dip 25°W.
Foliation dip 13°W.
Foliation flat.
Finely laminated diopside layer.
Schist bands in pegmatite
Foliation dip 16°W.
Foliation dip 40°W
Foliation dip 40°W.
Foliation dip 35°W.
Schist and pegmatite in normal contact.
Strong shear.
Foliation dip 23°W.
Pegmatite contact str N0°E
Foliation cut off by pegmatite
50% pegmatite
Foliation dip 27°W.
— 685+00
NORTH
FLOOR PLAN
SOUTH
Strong.
N30E 80
50 N5E
85 N21E
Striae dip 23°N.
74 N21E
80 N41E
Strong.
72 N31E
LOCATION AND DESCRIPTION OF SPECIMEN
—690+00 Biotite schist with pegmatite streaks.
—689+50 Biotite schist with pegmatite streaks.
—689+00 Carbonate rock with greenish diopside bands.
—688+50 Pegmatite with sulphide and scattered hornblende.
—688+00 Biotite streaked pegmatite with schist remnant.
—687+50 Quartzose biotite schist.
—687+00 Flaky biotite schist with pegmatite ougen and streaks.
—686+00 Pegmatite with biotite folia.
—685+00 Pegmatite with garnet.
N
GEOLOGIC SECTION NORTH WALL
— 685+00
Crush
Foliation dip 19°W
Crumpling of Schist.
Foliation Strike N16°E. Dip 28°W.
Lowangle slip Str. N11°E, Dip 17E
Calcite coated
Foliation dip 18°W.
Laminated schist. Some green banding.
Striae dip 30°N.
Foliation 12°W
Some diopside in brown biotite schist. Strong quartz pegmatite banding.
Black biotite schist close to the pegmatite.
Strongly banded green diopside layers. May represent original limestone.
Granitized schist with abundant garnets.
Biotite pegmatite.
Pegmatite with bands of schist.
Schist with numerous lenses and bands of pegmatite.
— 680+00
NORTH
FLOOR PLAN
SOUTH
N51E 80
87 N11E
Fracture zone
03 N38E
85 N11E
85 N6E
N54E 80
N76E 80
58 N16E
N66E 80
N84W 80
LOCATION AND DESCRIPTION OF SPECIMEN
—685+00 Pegmatite with garnet.
—684+00 Biotite schist with bands and streaks of pegmatite
—683+00 Feldspathic quartz biotite schist and pegmatite bands with graphite flakes.
—682+00 Granite with sulphide.
—681+00 Pegmatite
—680+00 Flaky biotite schist and pegmatite with graphite flakes.
LEGEND
Pegmatite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx.
Strike
Bearing Degrees
JOINTS
Tunnel N86°33'W.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION - STA. 680+00 TO 690+00


GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
710+00
Foliation dip 27°W.
50% pegmatite in lenses separated by thin schist bands The pegmatite also incloses bands of schist.
Foliation 21°W.
Coarse pegmatite with thin streaks of schist and biotite.
Quartz vein.
Schist streak within the pegmatite
95% pegmatite, yet streaked with coarse schist.
Fully 50% pegmatite
Foliation Strike N0°E Dip 21°W.
Pegmatite with streaks of schist.
Gneissoid granite or granitized.
60-75% pegmatite
Foliation dip 21°W.
Gray gneissoid granite or granitized schist.
That there has been much replacement is shown by the amount of granitization. What appears to be schist is largely gneissoid granite yet carries the pegmatite lenses.
More schistose
Contacts are gradational.
Streaked pegmatite
Quartzose schist.
½" Open fissure
No striations visible.
705+00
Striae horizontal.
Weak.
Strong
Weak
Closely spaced and parallel.
Strong
weak
weak
Parallel set of weak joints
90 N45E
90 N0E
N40E 87
N30E 90
90 N56E
N40E 90
N57E 87
N57E 82
N45E 80 N45E 86
N45E 80 N55E 80
21 N0 E N46E 85
80 N40E
710+00 Flaky biotite schist with pegmatite streaks
709+50 Greenish pegmatite.
709+00 Biotite schist with feldspar augen with sulphide
708+50 Pegmatite with biotite folia.
708+00 Foliated granite
707+50 Partially granitized schist with pegmatite.
707+00 Granitized schist.
706+50 Pegmatite.
706+00 Feldspathic biotite schist with pegmatite bands and streaks.
705+50 Feldspathic biotite schist with pegmatite bands and streaks
705+00 Feldspathic biotite schist with pegmatite
705+00
Foliation dip 25°W. Schist with bands of pegmatite which contain black biotite
Foliation dip 33°W. 40-50% pegmatite.
4' Gneissoid granite.
Foliation dip 20°W
Foliation dip 10°W. Banded injection. 20% pegmatite
Foliation dip 30°W.
Schist with numerous pegmatite lenses.
Pegmatite contains streaks of biotite.
Foliation dip 17°W.
Schist with pegmatite bands, lenses and small augen. 40-50% Pegmatite
Vein quartz.
Contact of biotite pegmatite with banded injection biotite schist.
Open and slightly irregular.
Foliation dip 11°W
Foliation Strike N0°E Dip 25°W
1" quartz and calcite
Foliation dip 18°W. Schist with bands and lenses of pegmatite
700+00
weak
Weak
Weak
Slight crag.
All weak joints.
Striae horizontal
Weak.
Strong
80 N40E
78 N33E
N40E 90
20 N0E
80 N33E
N15E 90 N33E 90
90 N30E
N76E 80
N10W 60
90 N5E 90 N15W
70 N30E
11-25 N0E
N66E 85
80 N10W
90 N46E
N0E 80 N56E 80
80 N16E
705+00 Feldspathic biotite schist with pegmatite
704+50 Quartzose biotite schist
704+00 Partially granitized schist with pegmatite streaks.
703+50 Pegmatite with biotite folia.
703+00 Pegmatite
702+50 Quartzose biotite schist with pegmatite
702+00 Biotite schist with pegmatite streaks and augen.
701+50 Quartzose biotite and sericitic pegmatite
701+00 quartzose biotite schist with sericitic pegmatite
700+50 Biotite granite with pegmatite band
700+00 Flaky biotite schist with garnet.
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

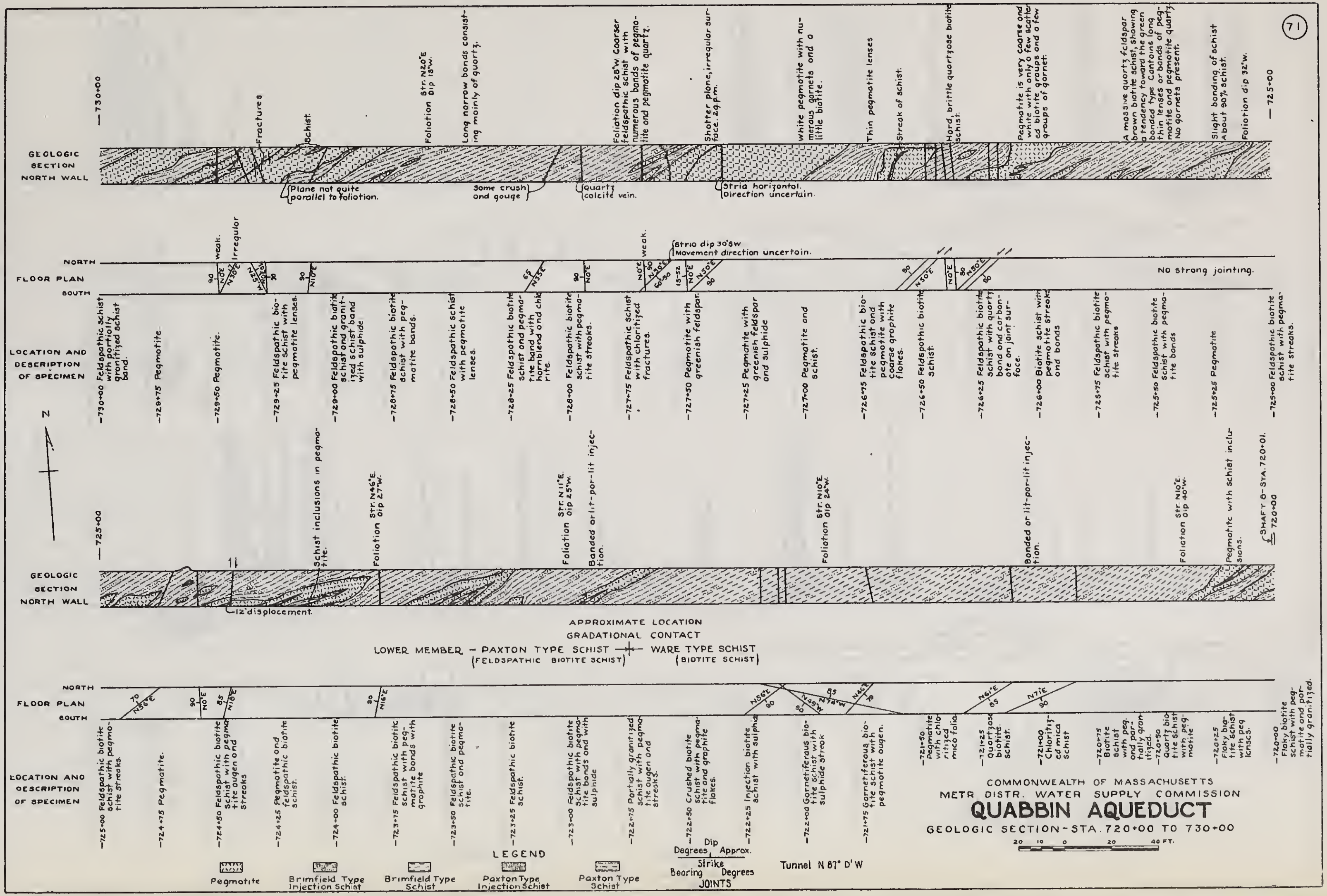
GEOLOGIC SECTION - STA. 700+00 TO 710+00

LEGEND

▨	Pegmatite
▨	Brimfield Type Injection Schist
▨	Brimfield Type Schist

Dip
Degrees Appro
Strike
Bearing Degrees
JOINTS

Tunnel N86°33'W.

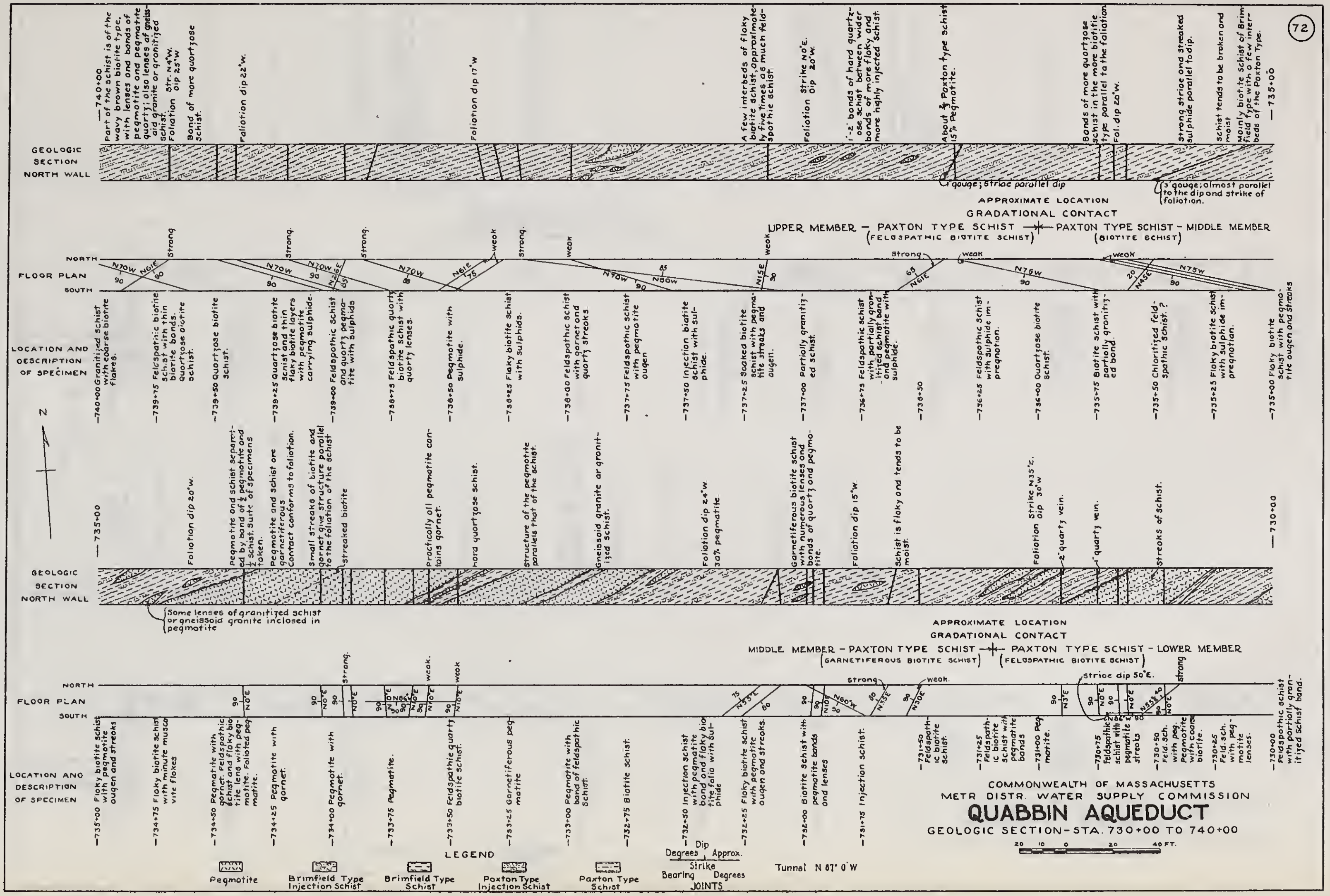


71
GEOLOGIC SECTION NORTH WALL
—730+00
Fractures
Schist.
Plane not quite parallel to foliation.
Foliation Str. N20°E Dip 15°W.
Long narrow bands consisting mainly of quartz.
Some crush and gouge
Foliation dip 28°W Coarser feldspathic schist with numerous bands of pegmatite and pegmatite quartz.
Quartz calcite vein.
Shatter plane, irregular surface. 2g.p.m.
Stria horizontal. Direction uncertain.
White pegmatite with numerous garnets and a little biotite.
Thin pegmatite lenses
Streak of schist.
Hard, brittle quartzose biotite schist.
Pegmatite is very coarse and white with only a few scattered biotite groups and a few groups of garnet.
A massive quartz feldspar brown biotite schist, showing a tendency toward the green banded type. Contains long thin lenses or bands of pegmatite and pegmatite quartz. No garnets present.
Slight banding of schist About 90% schist.
Foliation dip 32°W.
— 725+00
NORTH
FLOOR PLAN
SOUTH
weak.
Irregular
90
N0°E
N30°E
N52°W
N20°E
70
90
N10°E
65
N35°E
90
N0°E
weak.
N0°E
90
N30°E
60-90
Stria dip 30°SW
Movement direction uncertain.
15-52
N0°E
N50°E
90
90
N50°E
N0°E
80
N50°E
80
No strong jointing.
LOCATION AND DESCRIPTION OF SPECIMEN
—730+00 Feldspathic schist with partially granitized schist band.
—729+75 Pegmatite.
—729+50 Pegmatite.
—729+25 Feldspathic biotite schist with pegmatite lenses.
—729+00 Feldspathic biotite schist and granitized schist band with sulphide
—728+75 Feldspathic biotite schist with pegmatite bands.
—728+50 Feldspathic schist with pegmatite lenses.
—728+25 Feldspathic biotite schist and pegmatite band with hornblend and chlorite.
—728+00 Feldspathic biotite schist with pegmatite streaks.
—727+75 Feldspathic schist with chloritized fractures.
—727+50 Pegmatite with greenish feldspar.
—727+25 Pegmatite with greenish feldspar and sulphide
—727+00 Pegmatite and schist.
—726+75 Feldspathic biotite schist and pegmatite with coarse graphite flakes.
—726+50 Feldspathic biotite schist.
—726+25 Feldspathic biotite schist with quartz band and carbonate on joint surface.
—726+00 Biotite schist with pegmatite streaks and bands
—725+75 Feldspathic biotite schist with pegmatite streaks
—725+50 Feldspathic biotite schist with pegmatite bands
—725+25 Pegmatite
—725+00 Feldspathic biotite schist with pegmatite streaks.
N
GEOLOGIC SECTION NORTH WALL
—725+00
12' displacement.
Schist inclusions in pegmatite.
Foliation Str. N46°E. dip 27°W.
Foliation Str. N11°E. dip 25°W.
Banded or lit-par-lit injection.
Foliation Str. N10°E dip 24°W.
Banded or lit-par-lit injection.
Foliation Str N10°E. dip 40°W.
Pegmatite with schist inclusions.
SHAFT 8-STA. 720+01.
720+00
APPROXIMATE LOCATION
GRADATIONAL CONTACT
LOWER MEMBER – PAXTON TYPE SCHIST (FELDSPATHIC BIOTITE SCHIST)
WARE TYPE SCHIST (BIOTITE SCHIST)
NORTH
FLOOR PLAN
SOUTH
70
N36°E
90
N0°E
85
N18°E
90
N16°E
N56°E
90
90
N49°W
85
N74°W
N46°E
79
N61°E
85
N71°E
80
LOCATION AND DESCRIPTION OF SPECIMEN
—725+00 Feldspathic biotite schist with pegmatite streaks.
—724+75 Pegmatite.
—724+50 Feldspathic biotite schist with pegmatite augen and streaks
—724+25 Pegmatite and feldspathic biotite schist.
—724+00 Feldspathic biotite schist.
—723+75 Feldspathic biotite schist with pegmatite bands with graphite
—723+50 Feldspathic biotite schist and pegmatite.
—723+25 Feldspathic biotite schist.
—723+00 Feldspathic biotite schist with pegmatite bands and with sulphide
—722+75 Partially granitized schist with pegmatite augen and streaks.
—722+50 Crushed biotite schist with pegmatite and graphite flakes.
—722+25 Injection biotite schist with sulphide
—722+00 Garnetiferous biotite schist with sulphide streak
—721+75 Garnetiferous biotite schist with pegmatite augen.
—721+50 Pegmatite with chloritized mica folia.
—721+25 Quartzose biotite schist.
—721+00 Chloritized mica schist
—720+75 Biotite schist with peg. and partially granitized.
—720+50 Quartz biotite schist with pegmatite
—720+25 Flaky biotite schist with peg lenses.
—720+00 Flaky biotite schist with pegmatite and partially granitized.
LEGEND
Pegmatite
Brimfield Type Injection Schist
Brimfield Type Schist
Paxton Type Injection Schist
Paxton Type Schist
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 87° 0' W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

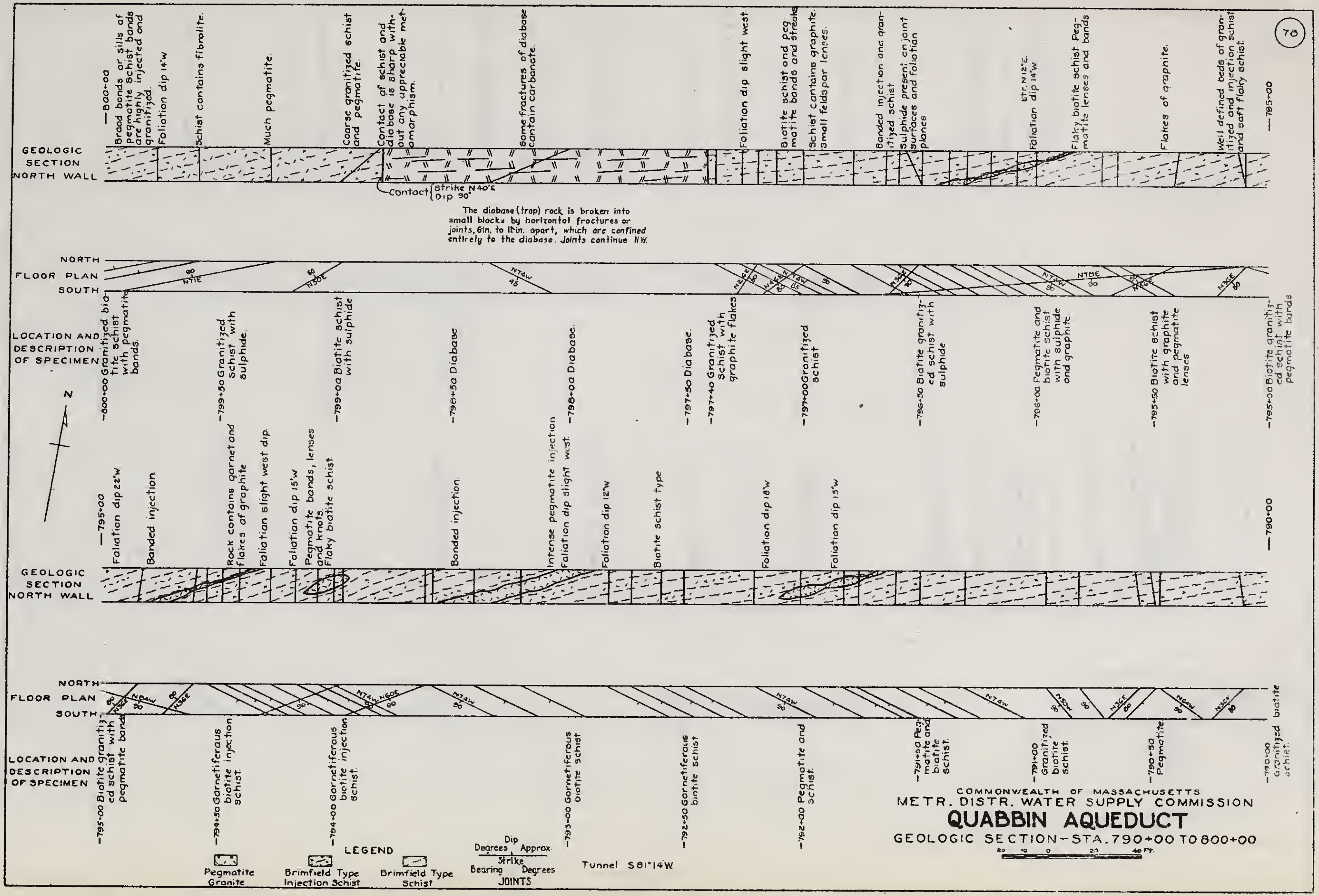
GEOLOGIC SECTION – STA. 720+00 TO 730+00


72
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
— 740+00
Part of the schist is of the wavy brown biotite type, with lenses and bands of pegmatite and pegmatite quartz; also lenses of gneissoid granite or granitized schist.
Foliation Str. N4°W. Dip 25°W
Band of more quartzose schist.
Foliation dip 22°W.
Foliation dip 17°W
A few interbeds of flaky biotite schist, approximately five times as much feldspathic schist
Foliation Strike N0°E. Dip 20°W.
1"-2" bands of hard quartzose schist between wider bands of more flaky and more highly injected schist.
About ⅔ Paxton type schist 15% Pegmatite.
1" gouge; striae parallel dip
Bands of more quartzose schist in the more biotitic type parallel to the foliation.
Fol. dip 20°W.
Strong striae and streaked sulphide parallel to dip.
Schist tends to be broken and moist
Mainly biotite schist of Brimfield type with a few interbeds of the Paxton Type.
— 735+00
3" gouge; almost parallel to the dip and strike of foliation.
APPROXIMATE LOCATION
GRADATIONAL CONTACT
UPPER MEMBER — PAXTON TYPE SCHIST (FELDSPATHIC BIOTITE SCHIST)
PAXTON TYPE SCHIST - MIDDLE MEMBER (BIOTITE SCHIST)
Strong
Strong.
weak
N70W
N61E
N26E
N80W
N15E
N61E
N76W
N45E
N75W
90
85
75
65
20
—740+00 Granitized schist with coarse biotite flakes.
—739+75 Feldspathic biotite schist with thin biotite bands. Quartzose biotite schist.
—739+50 Quartzose biotite schist.
—739+25 Quartzose biotite schist and thin flaky biotite layers with pegmatite carrying sulphide.
—739+00 Feldspathic schist and quartz pegmatite with sulphids
—738+75 Feldspathic quartz biotite schist with quartz lenses.
—738+50 Pegmatite with sulphide.
—738+25 Flaky biotite schist with sulphids.
—738+00 Feldspathic schist with garnet and quartz streaks
—737+75 Feldspathic schist with pegmatite augen
—737+50 Injection biotite schist with sulphide.
—737+25 Soaked biotite schist with pegmatite streaks and augen.
—737+00 Partially granitized schist.
—736+75 Feldspathic schist with partially granitized schist band and pegmatite with sulphide.
—736+50
—736+25 Feldspathic schist with sulphide impregnation.
—736+00 Quartzose biotite schist.
—735+75 Biotite schist with partially granitized band.
—735+50 Chloritized feldspathic schist. ?
—735+25 Flaky biotite schist with sulphide impregnation.
—735+00 Flaky biotite schist with pegmatite augen and streaks
— 735+00
Foliation dip 20°W.
Pegmatite and schist separated by band of ½ pegmatite and ½ schist. Suite of specimens taken.
Pegmatite and schist are garnetiferous Contact conforms to foliation.
Small streaks of biotite and garnet give structure parallel to the foliation of the schist
Streaked biotite
Practically all pegmatite contains garnet.
Hard quartzose schist.
Structure of the pegmatite parallels that of the schist.
Gneissoid granite or granitized schist.
Foliation dip 24°W. 30% pegmatite
Garnetiferous biotite schist with numerous lenses and bands of quartz and pegmatite.
Foliation dip 15°W.
Schist is flaky and tends to be moist.
Foliation Strike N35°E. Dip 30°W
2" quartz vein.
1" quartz vein.
Streaks of schist.
— 730+00
Some lenses of granitized schist or gneissoid granite inclosed in pegmatite
APPROXIMATE LOCATION
GRADATIONAL CONTACT
MIDDLE MEMBER - PAXTON TYPE SCHIST (GARNETIFEROUS BIOTITE SCHIST)
PAXTON TYPE SCHIST - LOWER MEMBER (FELDSPATHIC BIOTITE SCHIST)
Strong.
weak.
weak
strong
striae dip 50°E.
N0°E
N86°W
N10°E
N55°E
N60°W
N35°E
N30E
N3°E
N55E
90
80
75
—735+00 Flaky biotite schist with pegmatite augen and streaks
—734+75 Flaky biotite schist with minute muscovite flakes
—734+50 Pegmatite with garnet. Feldspathic schist and flaky biotite lens with pegmatite. Foliated pegmatite.
—734+25 Pegmatite with garnet.
—734+00 Pegmatite with garnet.
—733+75 Pegmatite.
—733+50 Feldspathic quartz biotite schist.
—733+25 Garnetiferous pegmatite
—733+00 Pegmatite with band of feldspathic schist.
—732+75 Biotite schist.
—732+50 Injection schist with pegmatite band and flaky biotite folia with sulphide
—732+25 Flaky biotite schist with pegmatite augen and streaks.
—732+00 Biotite schist with pegmatite bands and lenses
—731+75 Injection schist.
—731+50 Feldspathic biotite schist.
—731+25 Feldspathic biotite schist with pegmatite bands
—731+00 Pegmatite.
—730+75 Feldspathic schist with pegmatite streaks
—730+50 Feld. sch. with peg. Pegmatite with coarse biotite.
—730+25 Feld. sch. with pegmatite lenses.
—730+00 Feldspathic schist with partially granitized schist band.
LEGEND
Pegmatite
Brimfield Type Injection Schist
Brimfield Type Schist
Paxton Type Injection Schist
Paxton Type Schist
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel N 87° 0' W
20 10 0 20 40 FT.

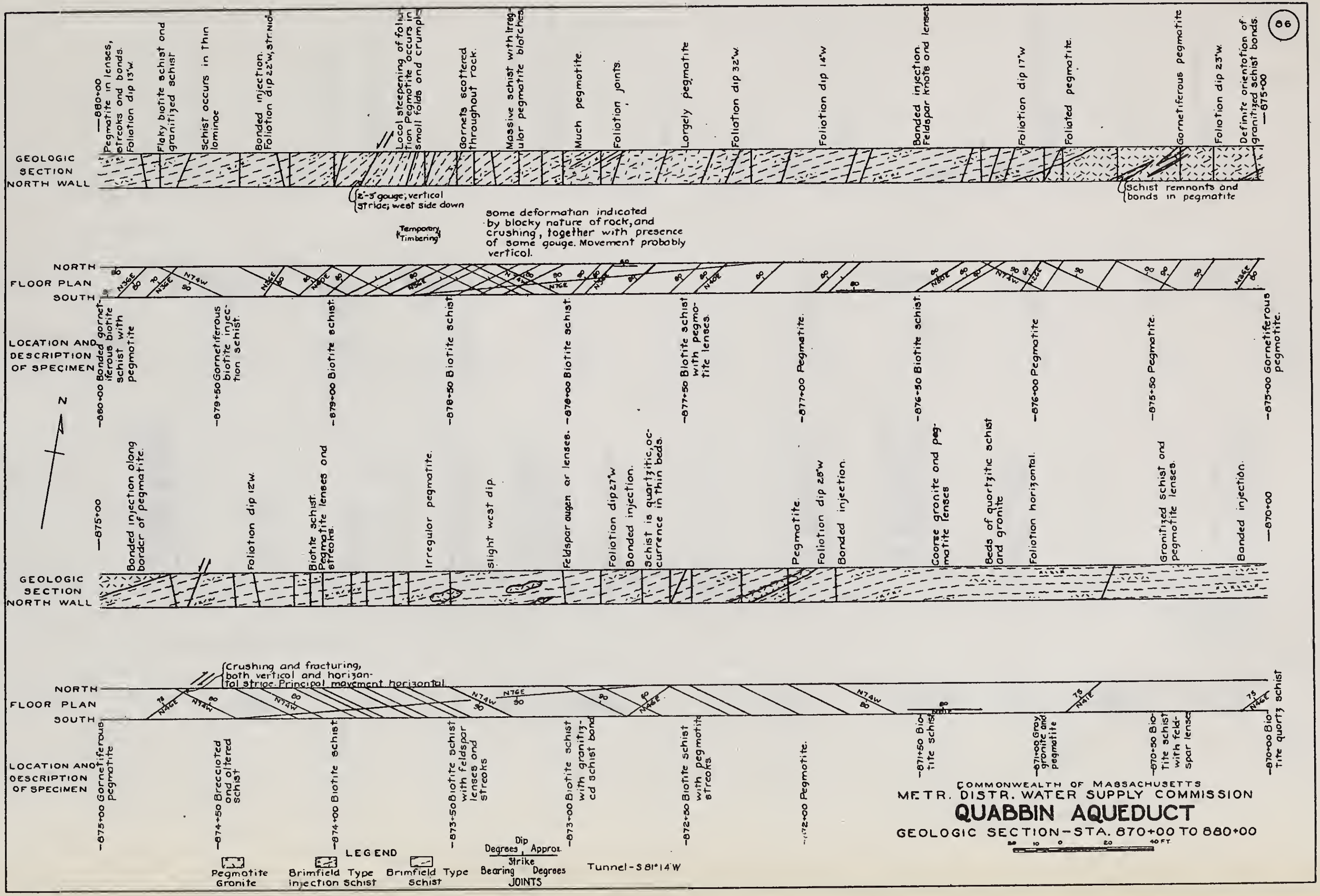
COMMONWEALTH OF MASSACHUSETTS
METR DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 730+00 TO 740+00


GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
—800+00
Broad bands or sills of pegmatite Schist bands are highly injected and granitized.
Foliation dip 14°W
Schist contains fibrolite.
Much pegmatite.
Coarse granitized schist and pegmatite.
Contact of schist and diabase is sharp without any appreciable metamorphism.
Some fractures of diabase contain carbonate.
Contact { Strike N40°E Dip 90°
The diabase (trap) rock is broken into small blocks by horizontal fractures or joints, 6in. to 18in. apart, which are confined entirely to the diabase. Joints continue NW.
Foliation dip slight west
Biotite schist and pegmatite bands and streaks
Schist contains graphite. Small feldspar lenses.
Banded injection and granitized schist
Sulphide present on joint surfaces and foliation planes
Str. N12°E. Foliation dip 14°W
Flaky biotite schist Pegmatite lenses and bands
Flakes of graphite.
Well defined beds of granitized and injection schist and soft flaky schist.
—795+00
N71E
80
N50E
60
N74W
45
N26E
80
N46E
80
N74W
65
80
N30E
80
N74W
80
N78E
80
N56E
80
N36E
80
—800+00 Granitized biotite schist with pegmatite bands.
—799+50 Granitized schist with sulphide.
—799+00 Biotite schist with sulphide
—798+50 Diabase
—798+00 Diabase.
—797+50 Diabase.
—797+40 Granitized schist with graphite flakes
—797+00 Granitized schist
—796+50 Biotite granitized schist with sulphide
—796+00 Pegmatite and biotite schist with sulphide and graphite.
—795+50 Biotite schist with graphite and pegmatite lenses
—795+00 Biotite granitized schist with pegmatite bands
N
—795+00
Foliation dip 22°W
Banded injection.
Rock contains garnet and flakes of graphite
Foliation slight west dip.
Foliation dip 15°W
Pegmatite bands, lenses and knots.
Flaky biotite schist.
Banded injection.
Intense pegmatite injection
Foliation dip slight west.
Foliation dip 12°W
Biotite schist type
Foliation dip 18°W
Foliation dip 15°W
—790+00
80
N36E
N04W
80
80
N36E
80
N74W
N60E
80
N74W
80
N74W
80
N74W
N50W
80
80
N36E
80
80
N64W
N36E
80
—795+00 Biotite granitized schist with pegmatite bands
—794+50 Garnetiferous biotite injection schist.
—794+00 Garnetiferous biotite injection schist.
—793+00 Garnetiferous biotite schist
—792+50 Garnetiferous biotite schist
—792+00 Pegmatite and schist.
—791+50 Pegmatite and biotite schist.
—791+00 Granitized biotite schist.
—790+50 Pegmatite.
—790+00 Granitized biotite schist.
LEGEND
Pegmatite Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S81°14W
20 10 0 20 40 FT.

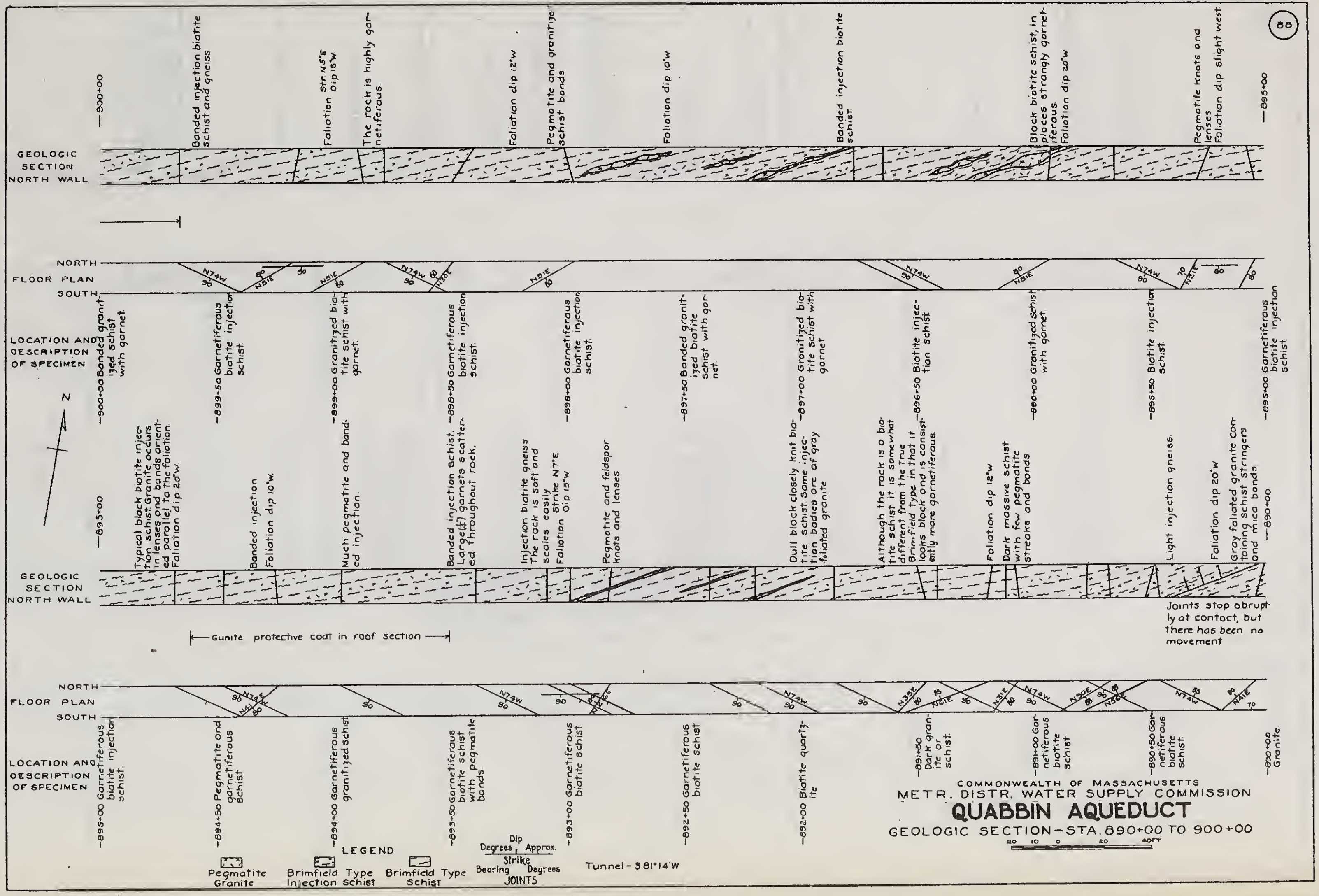
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 790+00 TO 800+00


GEOLOGIC SECTION NORTH WALL
—880+00
Pegmatite in lenses, streaks and bands. Foliation dip 13°W.
Flaky biotite schist and granitized schist
Schist occurs in thin laminae
Banded injection. Foliation dip 22°W, str N10
Local steepening of foliation Pegmatite occurs in small folds and crumpl
Garnets scattered throughout rock.
Massive schist with irregular pegmatite blotches
Much pegmatite.
Foliation joints.
Largely pegmatite
Foliation dip 32°W.
Foliation dip 14°W
Banded injection. Feldspar knots and lenses
Foliation dip 17°W
Foliated pegmatite.
Garnetiferous pegmatite
Foliation dip 23°W.
Definite orientation of granitized schist bands.
—875+00
2'-3' gouge; vertical striae; west side down
Schist remnants and bands in pegmatite
Some deformation indicated by blocky nature of rock, and crushing, together with presence of some gouge. Movement probably vertical.
Temporary Timbering
NORTH
FLOOR PLAN
SOUTH
N36E
N36E
N74W
N46E
N80E
N76E
N40E
N80E
N74W
N22E
N46E
LOCATION AND DESCRIPTION OF SPECIMEN
—880+00 Banded garnetiferous biotite schist with pegmatite
—879+50 Garnetiferous biotite injection schist.
—879+00 Biotite schist.
—878+50 Biotite schist
—878+00 Biotite schist.
—877+50 Biotite schist with pegmatite lenses.
—877+00 Pegmatite.
—876+50 Biotite schist.
—876+00 Pegmatite
—875+50 Pegmatite.
—875+00 Garnetiferous pegmatite.
N
—875+00
Banded injection along border of pegmatite.
Foliation dip 12°W.
Biotite schist. Pegmatite lenses and streaks.
Irregular pegmatite.
Slight west dip.
Feldspar augen or lenses.
Foliation dip 27°W
Banded injection.
Schist is quartzitic, occurrence in thin beds.
Pegmatite.
Foliation dip 28°W
Banded injection.
Coarse granite and pegmatite lenses
Beds of quartzitic schist and granite
Foliation horizontal.
Granitized schist and pegmatite lenses.
Banded injection.
—870+00
GEOLOGIC SECTION NORTH WALL
Crushing and fracturing, both vertical and horizontal striae. Principal movement horizontal
NORTH
FLOOR PLAN
SOUTH
N46E
N74W
N74W
N74W
N76E
N46E
N74W
N41E
N46E
LOCATION AND DESCRIPTION OF SPECIMEN
—875+00 Garnetiferous pegmatite
—874+50 Brecciated and altered schist
—874+00 Biotite schist
—873+50 Biotite schist with feldspar lenses and streaks
—873+00 Biotite schist with granitized schist band
—872+50 Biotite schist with pegmatite streaks
—872+00 Pegmatite.
—871+50 Biotite schist
—871+00 Gray granite and pegmatite
—870+50 Biotite schist with feldspar lenses
—870+00 Biotite quartz schist
LEGEND
Pegmatite Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel-S 81°14'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

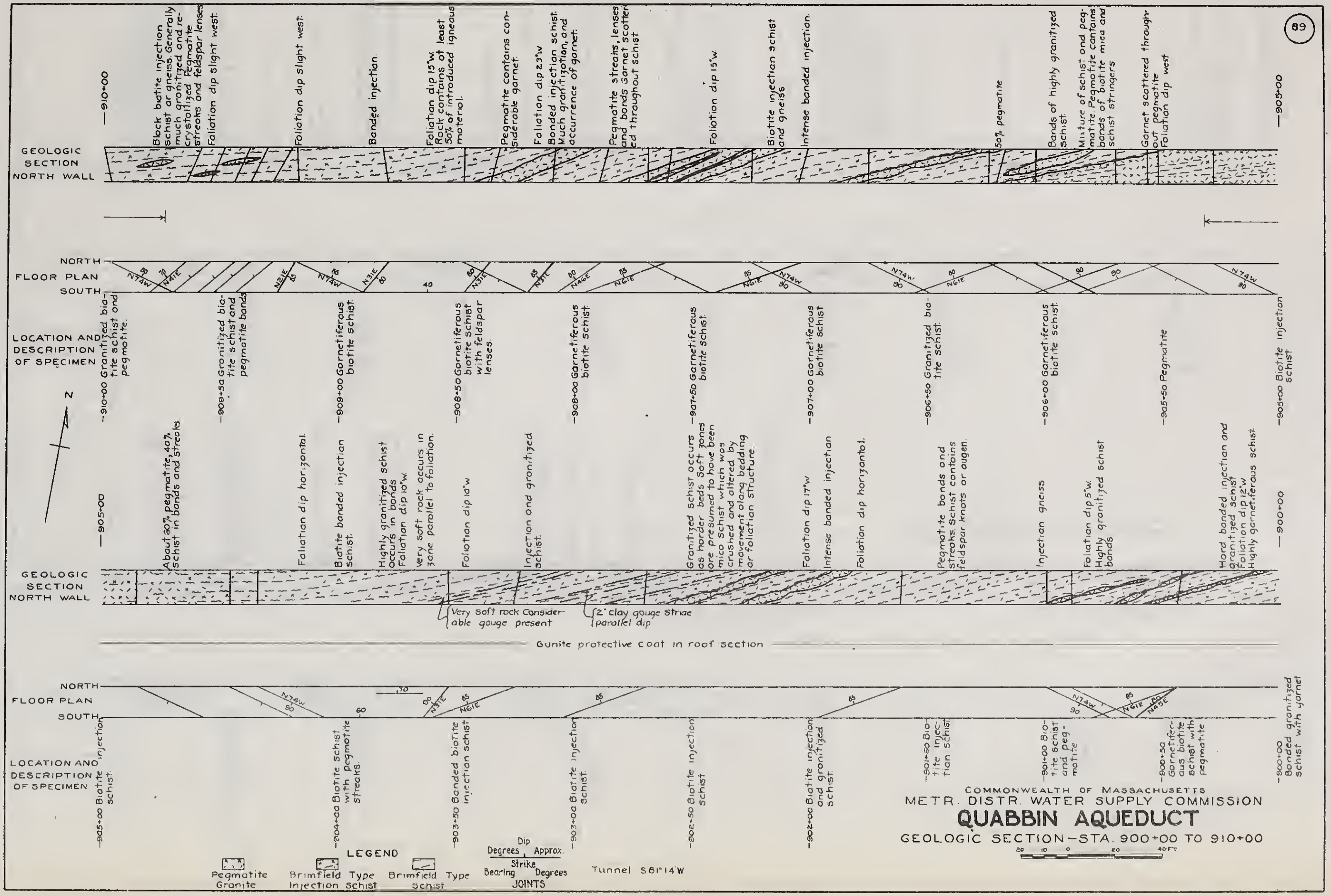
GEOLOGIC SECTION–STA. 870+00 TO 880+00


88
GEOLOGIC SECTION NORTH WALL
—900+00
Banded injection biotite schist and gneiss
Foliation Str. N5°E Dip 18°W
The rock is highly garnetiferous.
Foliation dip 12°W
Pegmatite and granitize schist bonds
Foliation dip 10°W
Banded injection biotite schist.
Black biotite schist, in places strongly garnetiferous. Foliation dip 20°W
Pegmatite knots and lenses Foliation dip slight west
—895+00
NORTH FLOOR PLAN SOUTH
N74W 90
N51E 80
30
N51E
N74W 90
N30E 80
N51E 80
N74W 90
N51E 80
N74W 90
70 N51E 80
80
LOCATION AND DESCRIPTION OF SPECIMEN
—900+00 Banded granitized schist with garnet.
—899+50 Garnetiferous biotite injection schist.
—899+00 Granitized biotite schist with garnet.
—898+50 Garnetiferous biotite injection schist.
—898+00 Garnetiferous biotite injection schist.
—897+50 Banded granitized biotite schist with garnet.
—897+00 Granitized biotite schist with garnet
—896+50 Biotite injection schist.
—896+00 Granitized schist with garnet.
—895+50 Biotite injection schist.
—895+00 Garnetiferous biotite injection schist.
N
—895+00
Typical black biotite injection schist. Granite occurs in lenses and bands oriented parallel to the foliation. Foliation dip 20°W.
Banded injection Foliation dip 10°W.
Much pegmatite and banded injection.
Banded injection schist. Large(?) garnets scattered throughout rock.
Injection biotite gneiss The rock is soft and scales easily Strike N7°E Foliation Dip 15°W
Pegmatite and feldspar knots and lenses
Dull black closely knit biotite schist. Same injection bodies are of gray foliated granite
Although the rock is a biotite schist it is somewhat different from the true Brimfield type in that it looks black and is consistently more garnetiferous.
Foliation dip 12°W
Dark massive schist with few pegmatite streaks and bands
Light injection gneiss.
Foliation dip 20°W
Gray foliated granite containing schist stringers and mica bands
—890+00
GEOLOGIC SECTION NORTH WALL
Gunite protective coat in roof section
Joints stop abruptly at contact, but there has been no movement
NORTH FLOOR PLAN SOUTH
90 N41E 80 N41W
90
N74W 90
90 N35E
90
N74W 90
90
N35E 80 85 N61E 90
N51E 80 N74W 90
N50E 85 90 N50E
N74W 85
80 N41E 70
LOCATION AND DESCRIPTION OF SPECIMEN
—895+00 Garnetiferous biotite injection schist.
—894+50 Pegmatite and garnetiferous schist
—894+00 Garnetiferous granitized schist
—893+50 Garnetiferous biotite schist with pegmatite bands.
—893+00 Garnetiferous biotite schist
—892+50 Garnetiferous biotite schist
—892+00 Biotite quartzite
—891+50 Dark granite or schist.
—891+00 Garnetiferous biotite schist
—890+50 Garnetiferous biotite schist.
—890+00 Granite.
LEGEND
Pegmatite Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees, Approx. Strike Bearing Degrees JOINTS
Tunnel - S 81°14' W
20 10 0 20 40FT

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

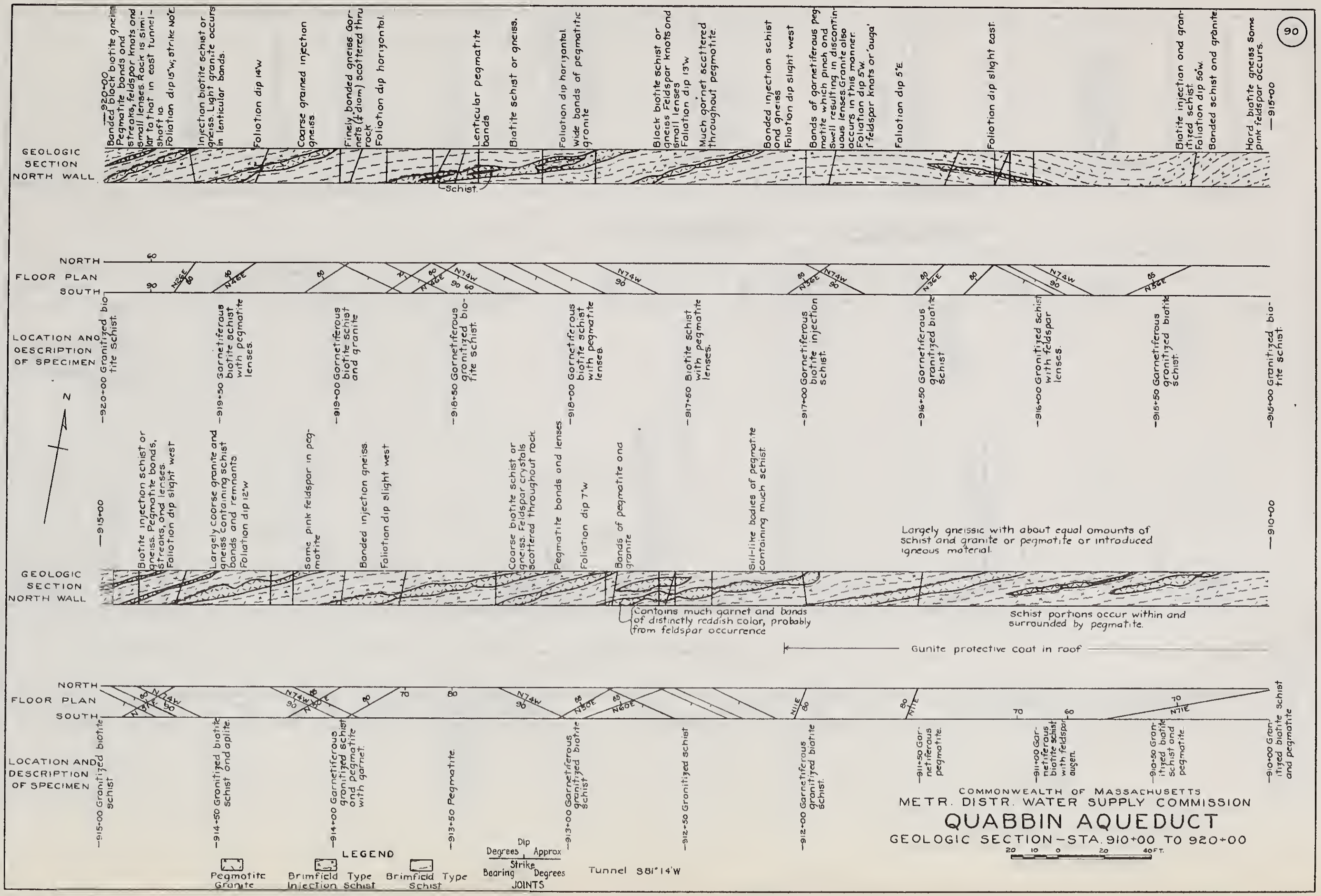
GEOLOGIC SECTION—STA. 890+00 TO 900+00


GEOLOGIC SECTION NORTH WALL
910+00
Block biotite injection schist or gneiss. Generally much granitized and re-crystallized Pegmatite streaks and feldspar lenses
Foliation dip slight west.
Foliation dip slight west.
Banded injection.
Foliation dip 15°w. Rock contains at least 50% of introduced igneous material.
Pegmatite contains considerable garnet.
Foliation dip 23°w
Banded injection schist. Much granitization, and occurrence of garnet.
Pegmatite streaks, lenses and bands Garnet scattered throughout schist
Foliation dip 15°w.
Biotite injection schist and gneiss
Intense banded injection.
50% pegmatite
Bands of highly granitized schist.
Mixture of schist and pegmatite. Pegmatite contains bands of biotite mica and schist stringers
Garnet scattered throughout pegmatite
Foliation dip west
905+00
NORTH
FLOOR PLAN
SOUTH
N74W
N41E
N21E
N31E
N46E
N61E
LOCATION AND DESCRIPTION OF SPECIMEN
910+00 Granitized biotite schist and pegmatite.
909+50 Granitized biotite schist and pegmatite bands
909+00 Garnetiferous biotite schist.
908+50 Garnetiferous biotite schist with feldspar lenses.
908+00 Garnetiferous biotite schist.
907+50 Garnetiferous biotite schist.
907+00 Garnetiferous biotite schist
906+50 Granitized biotite schist.
906+00 Garnetiferous biotite schist.
905+50 Pegmatite
905+00 Biotite injection schist
N
905+00
About 80% pegmatite, 40% schist in bands and streaks
Foliation dip horizontal.
Biotite banded injection schist.
Highly granitized schist occurs in bands Foliation dip 10°w.
Very soft rock occurs in zone parallel to foliation.
Foliation dip 10°w
Injection and granitized schist.
Granitized schist occurs as harder beds Soft zones are presumed to have been mica schist which was crushed and altered by movement along bedding or foliation structure.
Foliation dip 17°w
Intense banded injection
Foliation dip horizontal.
Pegmatite bands and streaks. Schist contains feldspar knots or augen.
Injection gneiss
Foliation dip 5°w.
Highly granitized schist bands
Hard banded injection and granitized schist
Foliation dip 12°w
Highly garnetiferous schist.
900+00
Very soft rock Considerable gouge present
2" clay gouge Striae parallel dip
Gunite protective coat in roof section
905+00 Biotite injection schist.
904+00 Biotite schist with pegmatite streaks.
903+50 Banded biotite injection schist
903+00 Biotite injection schist.
902+50 Biotite injection schist
902+00 Biotite injection and granitized schist.
901+50 Biotite injection schist
901+00 Biotite schist and pegmatite
900+50 Garnetiferous biotite schist with pegmatite
900+00 Banded granitized schist with garnet
LEGEND
Pegmatite Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40 FT

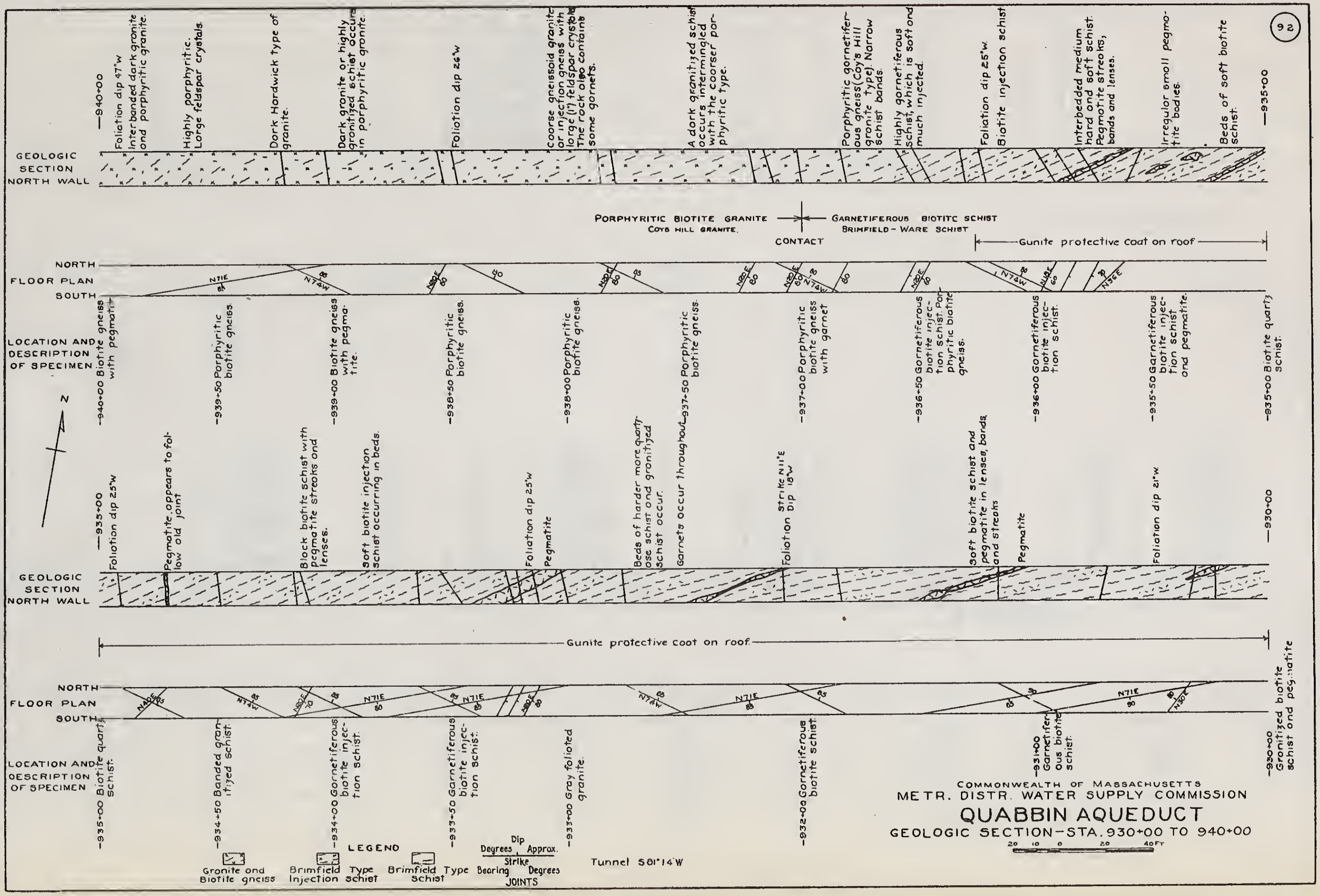
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

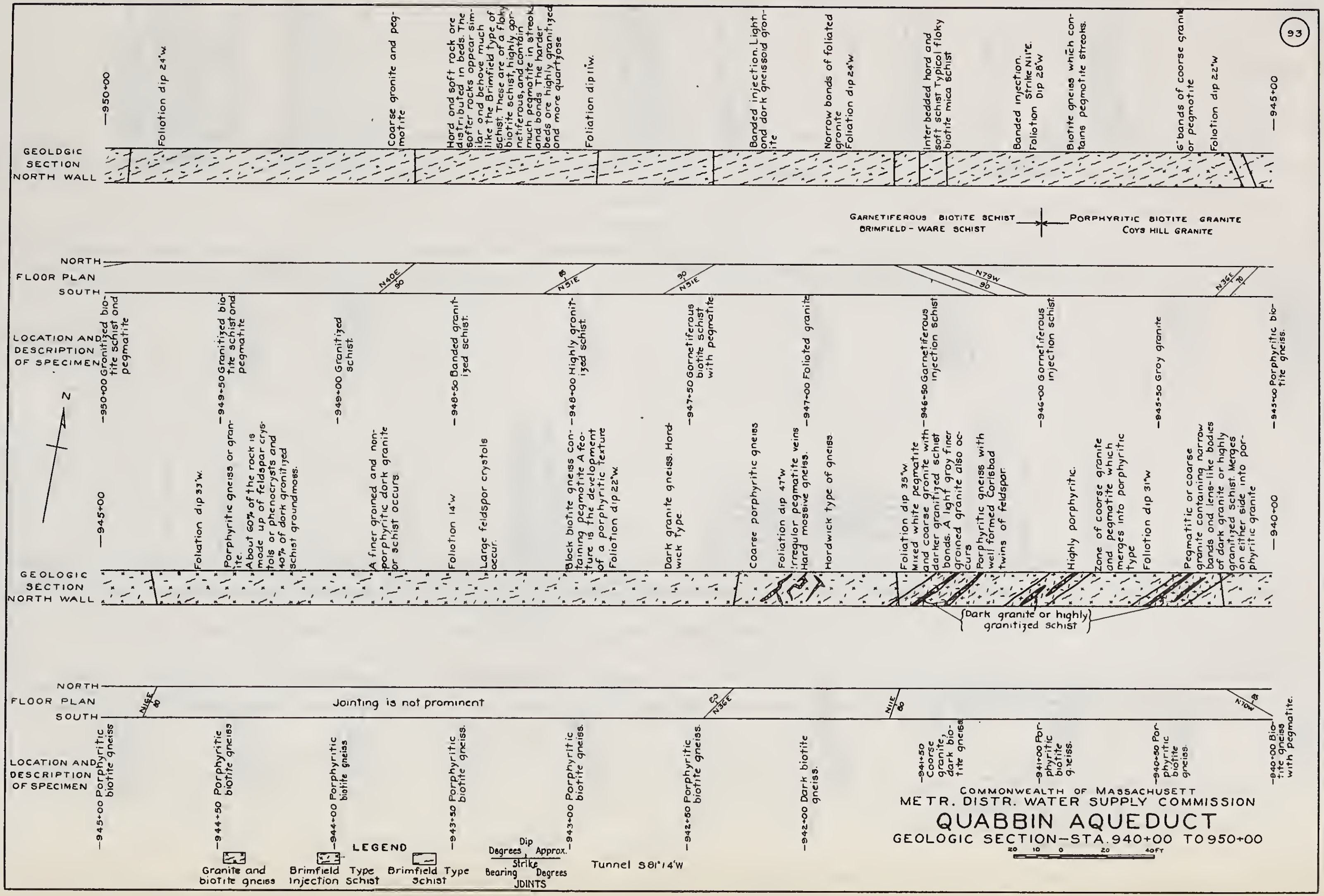
GEOLOGIC SECTION – STA. 900+00 TO 910+00


GEOLOGIC SECTION NORTH WALL
920+00
Banded black biotite gneiss. Pegmatite bands and streaks, feldspar knots and small lenses. Rock is similar to that in east tunnel-shaft 1a.
Foliation dip 15°W; strike N0°E
Injection biotite schist or gneiss. Light granite occurs in lenticular bands.
Foliation dip 14°W
Coarse grained injection gneiss.
Finely banded gneiss. Garnets (1/4" diam.) scattered thru rock
Foliation dip horizontal.
Lenticular pegmatite bands
Schist.
Biotite schist or gneiss.
Foliation dip horizontal.
Wide bands of pegmatitic granite
Black biotite schist or gneiss. Feldspar knots and small lenses
Foliation dip 13°W
Much garnet scattered throughout pegmatite.
Banded injection schist and gneiss
Foliation dip slight west
Bands of garnetiferous pegmatite which pinch and swell resulting in discontinuous lenses. Granite also occurs in this manner.
Foliation dip 5°W.
1" feldspar knots or 'auga'
Foliation dip 5°E
Foliation dip slight east.
Biotite injection and granitized schist.
Foliation dip 50°W.
Banded schist and granite.
Hard biotite gneiss. Some pink feldspar occurs.
915+00
NORTH
FLOOR PLAN
SOUTH
N26E
N46E
N46E
N74W
N74W
N36E
N74W
N36E
N74W
N36E
60
90
80
70
65
LOCATION AND DESCRIPTION OF SPECIMEN
920+00 Granitized biotite schist.
919+50 Garnetiferous biotite schist with pegmatite lenses.
919+00 Garnetiferous biotite schist and granite
918+50 Garnetiferous granitized biotite schist.
918+00 Garnetiferous biotite schist with pegmatite lenses.
917+50 Biotite schist with pegmatite lenses.
917+00 Garnetiferous biotite injection schist.
916+50 Garnetiferous granitized biotite schist
916+00 Granitized schist with feldspar lenses.
915+50 Garnetiferous granitized biotite schist.
915+00 Granitized biotite schist.
N
915+00
Biotite injection schist or gneiss. Pegmatite bands, streaks, and lenses.
Foliation dip slight west
Largely coarse granite and gneiss containing schist bands and remnants
Foliation dip 12°W
Some pink feldspar in pegmatite
Banded injection gneiss.
Foliation dip slight west
Coarse biotite schist or gneiss. Feldspar crystals scattered throughout rock.
Pegmatite bands and lenses.
Foliation dip 7°W
Bands of pegmatite and granite
Sill-like bodies of pegmatite containing much schist.
Largely gneissic with about equal amounts of schist and granite or pegmatite or introduced igneous material.
910+00
GEOLOGIC SECTION NORTH WALL
Contains much garnet and bands of distinctly reddish color, probably from feldspar occurrence
Schist portions occur within and surrounded by pegmatite.
Gunite protective coat in roof
NORTH
FLOOR PLAN
SOUTH
N37E
N74W
N74W
N50E
N74W
N50E
N60E
N11E
N11E
N71E
90
80
70
60
LOCATION AND DESCRIPTION OF SPECIMEN
915+00 Granitized biotite schist
914+50 Granitized biotite schist and aplite.
914+00 Garnetiferous granitized schist and pegmatite with garnet.
913+50 Pegmatite.
913+00 Garnetiferous granitized biotite schist
912+50 Granitized schist
912+00 Garnetiferous granitized biotite schist.
911+50 Garnetiferous pegmatite.
911+00 Garnetiferous biotite schist with feldspar augen.
910+50 Granitized biotite schist and pegmatite.
910+00 Granitized biotite schist and pegmatite
LEGEND
Pegmatite Granite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees, Approx
Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 910+00 TO 920+00


GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
940+00
Foliation dip 47°W
Interbanded dark granite and porphyritic granite.
Highly porphyritic. Large feldspar crystals.
Dark Hardwick type of granite.
Dark granite or highly granitized schist occurs in porphyritic granite.
Foliation dip 26°W
Coarse gneissoid granite or injection gneiss with large (1") feldspar crystals. The rock also contains some garnets.
A dark granitized schist occurs intermingled with the coarser porphyritic type.
Porphyritic garnetiferous gneiss (Coys Hill granite type). Narrow schist bands.
Highly garnetiferous schist, which is soft and much injected.
Foliation dip 25°W.
Biotite injection schist
Interbedded medium hard and soft schist. Pegmatite streaks, bands and lenses.
Irregular small pegmatite bodies.
Beds of soft biotite schist.
935+00
PORPHYRITIC BIOTITE GRANITE
COYS HILL GRANITE.
CONTACT
GARNETIFEROUS BIOTITC SCHIST
BRIMFIELD - WARE SCHIST
Gunite protective coat on roof
N71E
85
N74W
88
N30E
80
80
N30E
80
85
N30E
80
N30E
80
N74W
88
80
N30E
80
N74W
78
N13E
60
70
N36E
940+00 Biotite gneiss with pegmatite.
939+50 Porphyritic biotite gneiss.
939+00 Biotite gneiss with pegmatite.
938+50 Porphyritic biotite gneiss.
938+00 Porphyritic biotite gneiss.
937+50 Porphyritic biotite gneiss.
937+00 Porphyritic biotite gneiss with garnet
936+50 Garnetiferous biotite injection schist. Porphyritic biotite gneiss.
936+00 Garnetiferous biotite injection schist.
935+50 Garnetiferous biotite injection schist and pegmatite.
935+00 Biotite quartz schist.
N
935+00
Foliation dip 25°W
Pegmatite appears to follow old joint
Black biotite schist with pegmatite streaks and lenses.
Soft biotite injection schist occurring in beds.
Foliation dip 25°W
Pegmatite
Beds of harder more quartzose schist and granitized schist occur.
Garnets occur throughout
Foliation Strike N11°E Dip 18°W
Soft biotite schist and pegmatite in lenses, bands and streaks
Pegmatite
Foliation dip 21°W.
930+00
Gunite protective coat on roof.
N40E
85
N74W
85
N30E
70
85
N71E
80
85
N71E
85
N30E
80
N74W
85
N71E
85
85
85
90
N71E
90
80
N30E
935+00 Biotite quartz schist.
934+50 Banded granitized schist.
934+00 Garnetiferous biotite injection schist.
933+50 Garnetiferous biotite injection schist.
933+00 Gray foliated granite.
932+00 Garnetiferous biotite schist.
931+00 Garnetiferous biotite schist.
930+00 Granitized biotite schist and pegmatite
LEGEND
Granite and Biotite gneiss
Brimfield Type Injection schist
Brimfield Type Schist
Dip Degrees
Approx. Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40FT

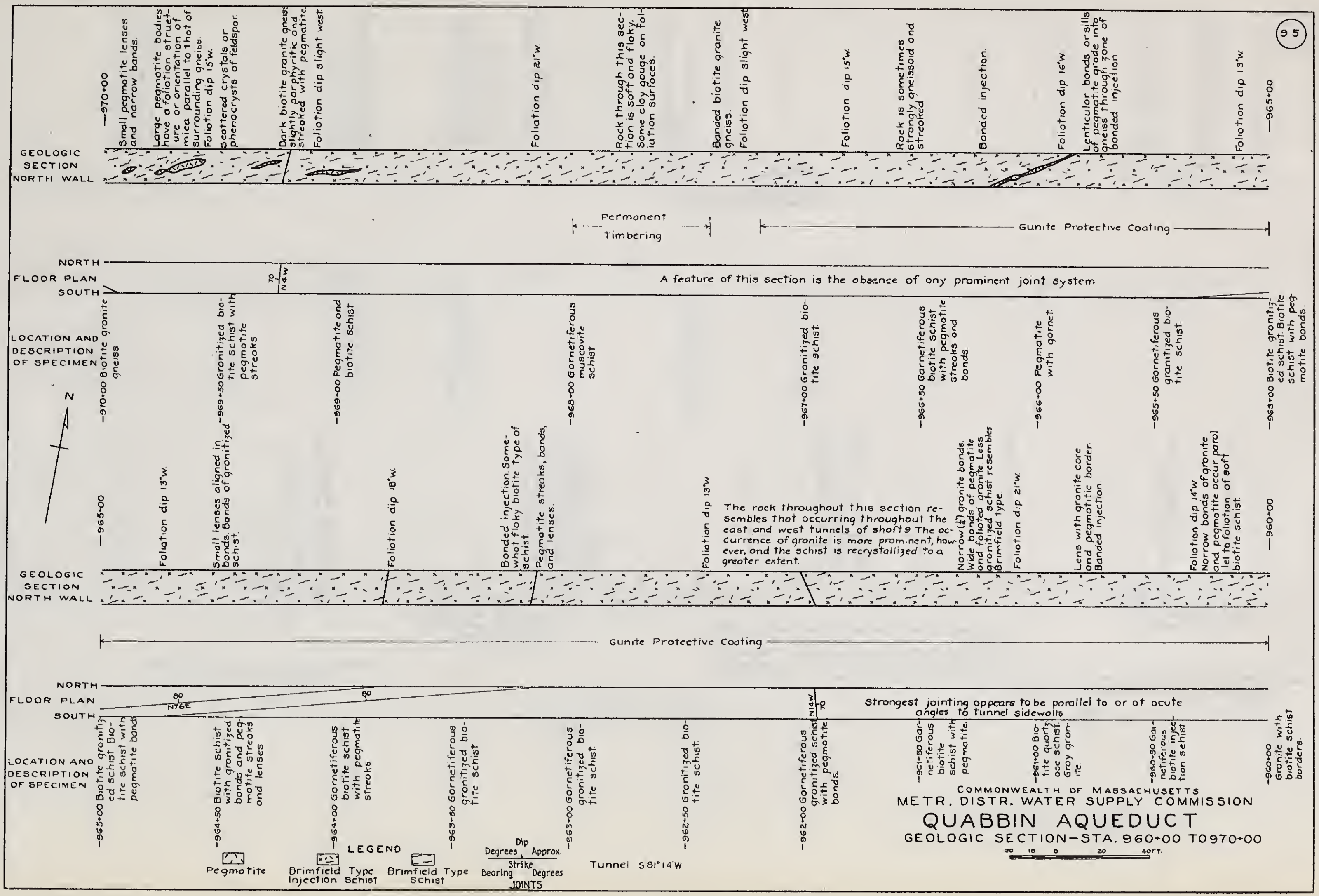
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION – STA. 930+00 TO 940+00


GEOLDGIC SECTION NORTH WALL
—950+00
Foliation dip 24°W.
Coarse granite and pegmatite
Hard and soft rock are distributed in beds. The softer rocks appear similar and behave much like the Brimfield type of schist. These are of a flaky biotite schist, highly garnetiferous, and contain much pegmatite in streaks and bands The harder beds are highly granitized and more quartzose
Foliation dip 11°W.
Banded injection. Light and dark gneissoid granite
Narrow bands of foliated granite
Foliation dip 24°W
Interbedded hard and soft schist Typical flaky biotite mica schist
Banded injection.
Foliation Strike N11°E. Dip 28°W
Biotite gneiss which contains pegmatite streaks.
6" bands of coarse granite or pegmatite
Foliation dip 22°W
—945+00
GARNETIFEROUS BIOTITE SCHIST
BRIMFIELD - WARE SCHIST
PORPHYRITIC BIOTITE GRANITE
COYS HILL GRANITE
NORTH
FLOOR PLAN
SOUTH
N40E 90
88 N51E
90 N51E
N79W 90
N36E 70
LOCATION AND DESCRIPTION OF SPECIMEN
—950+00 Granitized biotite schist and pegmatite
—949+50 Granitized biotite schist and pegmatite
—949+00 Granitized schist.
—948+50 Banded granitized schist.
—948+00 Highly granitized schist.
—947+50 Garnetiferous biotite schist with pegmatite
—947+00 Foliated granite
—946+50 Garnetiferous injection schist
—946+00 Garnetiferous injection schist.
—945+50 Gray granite
—945+00 Porphyritic biotite gneiss.
N
GEOLOGIC SECTION NORTH WALL
—945+00
Foliation dip 33°W.
Porphyritic gneiss or granite.
About 60% of the rock is made up of feldspar crystals or phenocrysts and 40% of dark granitized schist groundmass.
A finer grained and non-porphyritic dark granite or schist occurs.
Foliation 14°W
Large feldspar crystals occur.
Black biotite gneiss containing pegmatite A feature is the development of a porphyritic texture
Foliation dip 22°W.
Dark granite gneiss. Hardwick type
Coarse porphyritic gneiss
Foliation dip 47°W
Irregular pegmatite veins
Hard massive gneiss.
Hardwick type of gneiss.
Foliation dip 35°W
Mixed white pegmatite and coarse granite with darker granitized schist bands. A light gray finer grained granite also occurs
Porphyritic gneiss with well formed Carlsbad twins of feldspar.
Highly porphyritic.
Zone of coarse granite and pegmatite which merges into porphyritic type
Foliation dip 31°W
Pegmatitic or coarse granite containing narrow bands and lens-like bodies of dark granite or highly granitized schist. Merges on either side into porphyritic granite
—940+00
Dark granite or highly granitized schist
NORTH
FLOOR PLAN
SOUTH
N15E 80
Jointing is not prominent
N36E 83
N11E 80
N70W 81
LOCATION AND DESCRIPTION OF SPECIMEN
—945+00 Porphyritic biotite gneiss
—944+50 Porphyritic biotite gneiss
—944+00 Porphyritic biotite gneiss
—943+50 Porphyritic biotite gneiss.
—943+00 Porphyritic biotite gneiss.
—942+50 Porphyritic biotite gneiss.
—942+00 Dark biotite gneiss.
—941+50 Coarse granite, dark biotite gneiss
—941+00 Porphyritic biotite gneiss.
—940+50 Porphyritic biotite gneiss.
—940+00 Biotite gneiss with pegmatite.
LEGEND
Granite and biotite gneiss
Brimfield Type Injection Schist
Brimfield Type Schist
Dip Degrees Approx. Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40FT

COMMONWEALTH OF MASSACHUSETT
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION—STA. 940+00 TO 950+00

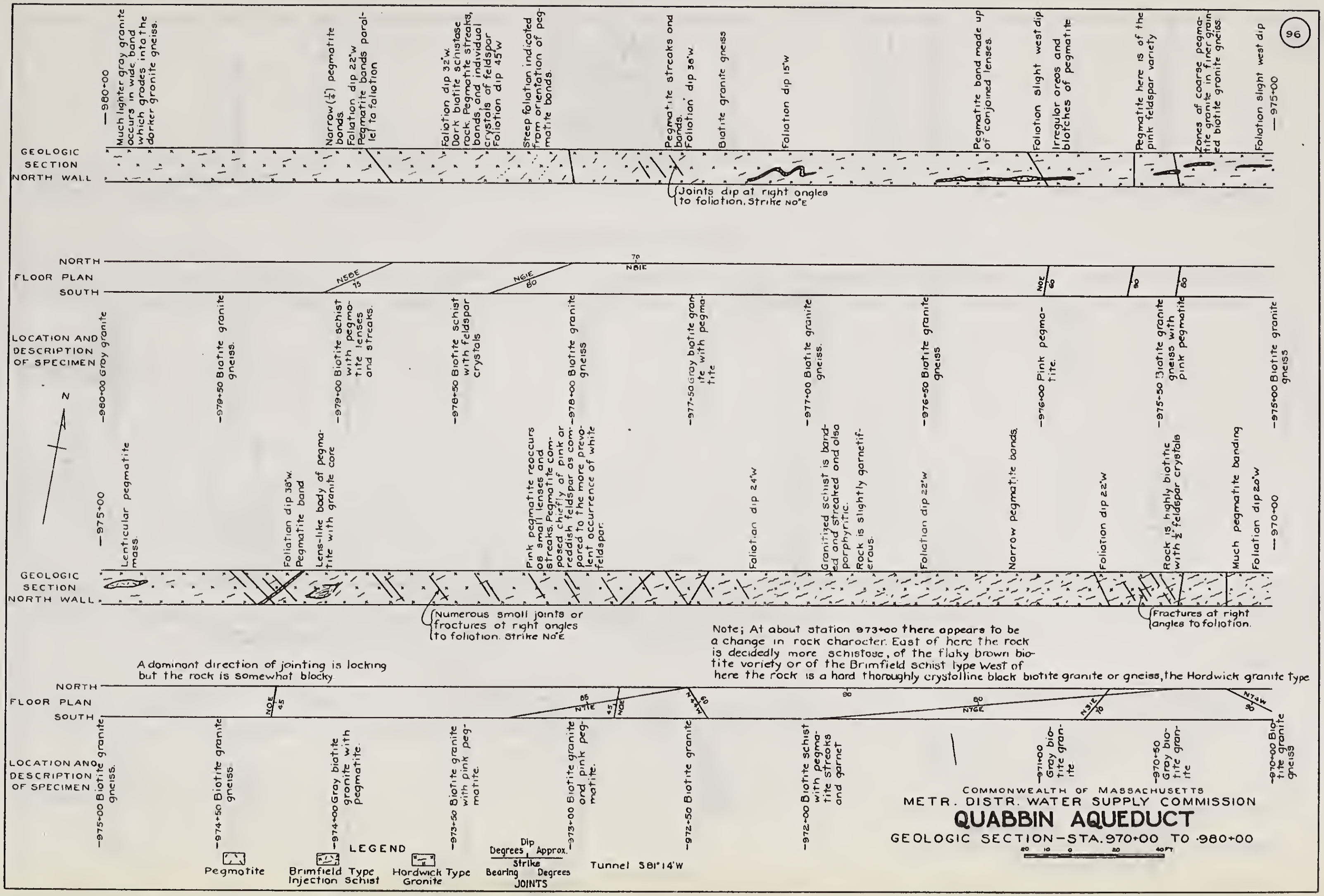

GEOLOGIC SECTION NORTH WALL
970+00
Small pegmatite lenses and narrow bands.
Large pegmatite bodies have a foliation structure or orientation of mica parallel to that of surrounding gneiss.
Foliation dip 15°W.
Scattered crystals or phenocrysts of feldspar.
Dark biotite granite gneiss slightly porphyritic and streaked with pegmatite.
Foliation dip slight west.
Foliation dip 21°W.
Rock through this section is soft and flaky. Some clay gouge on foliation surfaces.
Banded biotite granite gneiss.
Foliation dip slight west
Foliation dip 15°W.
Rock is sometimes strongly gneissoid and streaked
Banded injection.
Foliation dip 16°W
Lenticular bands or sills of pegmatite grade into gneiss through zone of banded injection
Foliation dip 13°W.
965+00
Permanent Timbering
Gunite Protective Coating
NORTH
FLOOR PLAN
SOUTH
70
N4°W
A feature of this section is the absence of any prominent joint system
LOCATION AND DESCRIPTION OF SPECIMEN
970+00 Biotite granite gneiss
969+50 Granitized biotite schist with pegmatite streaks
969+00 Pegmatite and biotite schist
968+00 Garnetiferous muscovite schist
967+00 Granitized biotite schist.
966+50 Garnetiferous biotite schist with pegmatite streaks and bands
966+00 Pegmatite with garnet.
965+50 Garnetiferous granitized biotite schist.
965+00 Biotite granitized schist Biotite schist with pegmatite bands.
N
965+00
Foliation dip 13°W.
Small lenses aligned in bands. Bands of granitized schist.
Foliation dip 18°W.
Banded injection. Somewhat flaky biotite type of schist.
Pegmatite streaks, bands, and lenses.
Foliation dip 13°W
Narrow(±) granite bands. Wide bands of pegmatite and foliated granite. Less granitized schist resembles Brimfield type.
Foliation dip 21°W.
Lens with granite core and pegmatitic border. Banded injection.
Foliation dip 14°W
Narrow bands of granite and pegmatite occur parallel to foliation of soft biotite schist.
960+00
GEOLOGIC SECTION NORTH WALL
Gunite Protective Coating
NORTH
FLOOR PLAN
SOUTH
80
N76E
80
N14W
Strongest jointing appears to be parallel to or at acute angles to tunnel sidewalls
LOCATION AND DESCRIPTION OF SPECIMEN
965+00 Biotite granitized schist Biotite schist with pegmatite bands
964+50 Biotite schist with granitized bands and pegmatite streaks and lenses
964+00 Garnetiferous biotite schist with pegmatite streaks
963+50 Garnetiferous granitized biotite schist
963+00 Garnetiferous granitized biotite schist.
962+50 Granitized biotite schist.
962+00 Garnetiferous granitized schist with pegmatite bands.
961+50 Garnetiferous biotite schist with pegmatite.
961+00 Biotite quartzose schist. Gray granite.
960+50 Garnetiferous biotite injection schist
960+00 Granite with biotite schist borders.
LEGEND
Pegmatite
Brimfield Type Injection Schist
Brimfield Type Schist
Dip
Degrees
Approx.
Strike
Bearing
Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40FT.

The rock throughout this section resembles that occurring throughout the east and west tunnels of shaft 9 The occurrence of granite is more prominent, however, and the schist is recrystallized to a greater extent.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

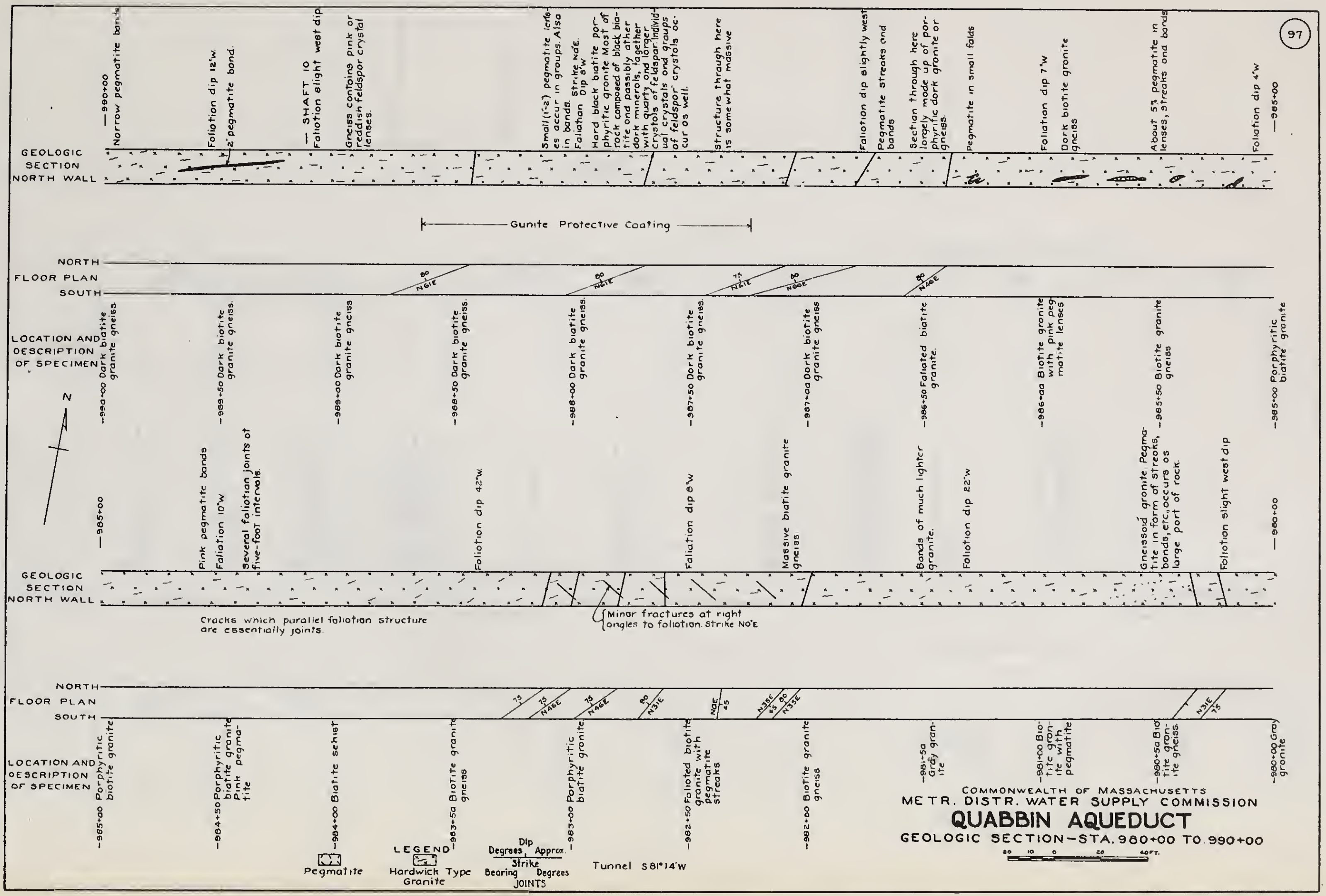
GEOLOGIC SECTION–STA. 960+00 TO 970+00


GEOLOGIC SECTION NORTH WALL
—980+00
Much lighter gray granite occurs in wide band which grades into the darker granite gneiss.
Narrow (1/4") pegmatite bands.
Foliation dip 22°w
Pegmatite bands parallel to foliation
Foliation dip 32°w.
Dark biotite schistose rock. Pegmatite streaks, bands, and individual crystals of feldspar
Foliation dip 45°w
Steep foliation indicated from orientation of pegmatite bands.
Pegmatite streaks and bands.
Foliation dip 38°w
Biotite granite gneiss
Foliation dip 15°w
Joints dip at right angles to foliation. Strike N0°E
Pegmatite band made up of conjoined lenses.
Foliation slight west dip
Irregular areas and blotches of pegmatite
Pegmatite here is of the pink feldspar variety
Zones of coarse pegmatite granite in finer grained biotite granite gneiss.
Foliation slight west dip
—975+00
NORTH
FLOOR PLAN
SOUTH
N58E 75
N61E 80
70 N81E
N0E 80
80
80
LOCATION AND DESCRIPTION OF SPECIMEN
N
-980+00 Gray granite
-979+50 Biotite granite gneiss.
-979+00 Biotite schist with pegmatite lenses and streaks.
-978+50 Biotite schist with feldspar crystals
-978+00 Biotite granite gneiss
-977+50 Gray biotite granite with pegmatite
-977+00 Biotite granite gneiss.
-976+50 Biotite granite gneiss
-976+00 Pink pegmatite.
-975+50 Biotite granite gneiss with pink pegmatite
-975+00 Biotite granite gneiss
—975+00
Lenticular pegmatite mass.
Foliation dip 38°w.
Pegmatite band
Lens-like body of pegmatite with granite core
Pink pegmatite reoccurs as small lenses and streaks. Pegmatite composed chiefly of pink or reddish feldspar as compared to the more prevalent occurrence of white feldspar.
Foliation dip 24°W
Granitized schist is banded and streaked and also porphyritic.
Rock is slightly garnetiferous.
Foliation dip 22°w
Narrow pegmatite bands.
Foliation dip 22°w
Rock is highly biotitic with 1/2" feldspar crystals
Much pegmatite banding
Foliation dip 20°w
—970+00
GEOLOGIC SECTION NORTH WALL
Numerous small joints or fractures at right angles to foliation. Strike N0°E
Fractures at right angles to foliation.
A dominant direction of jointing is lacking but the rock is somewhat blocky
Note; At about station 973+00 there appears to be a change in rock character. East of here the rock is decidedly more schistose, of the flaky brown biotite variety or of the Brimfield schist type West of here the rock is a hard thoroughly crystalline black biotite granite or gneiss, the Hardwick granite type
NORTH
FLOOR PLAN
SOUTH
N0E 45
85 N71E
45 N0E
N44W 60
80
80 N76E
N31E 70
N74W 80
LOCATION AND DESCRIPTION OF SPECIMEN
-975+00 Biotite granite gneiss.
-974+50 Biotite granite gneiss
-974+00 Gray biotite granite with pegmatite.
-973+50 Biotite granite with pink pegmatite.
-973+00 Biotite granite and pink pegmatite.
-972+50 Biotite granite
-972+00 Biotite schist with pegmatite streaks and garnet
-971+00 Gray biotite granite
-970+50 Gray biotite granite
-970+00 Biotite granite gneiss
LEGEND
Pegmatite
Brimfield Type Injection Schist
Hardwick Type Granite
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40 FT

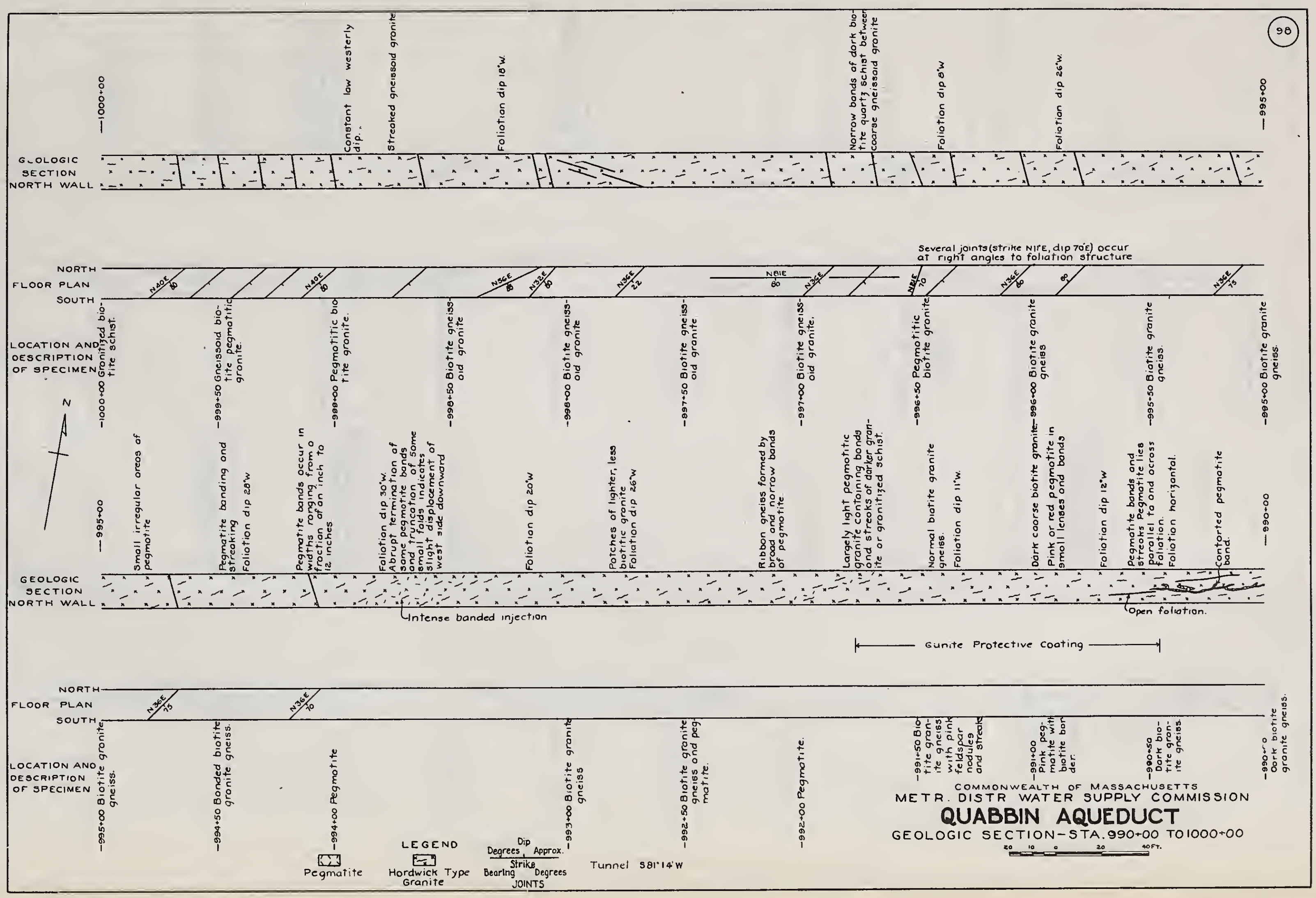
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 970+00 TO 980+00

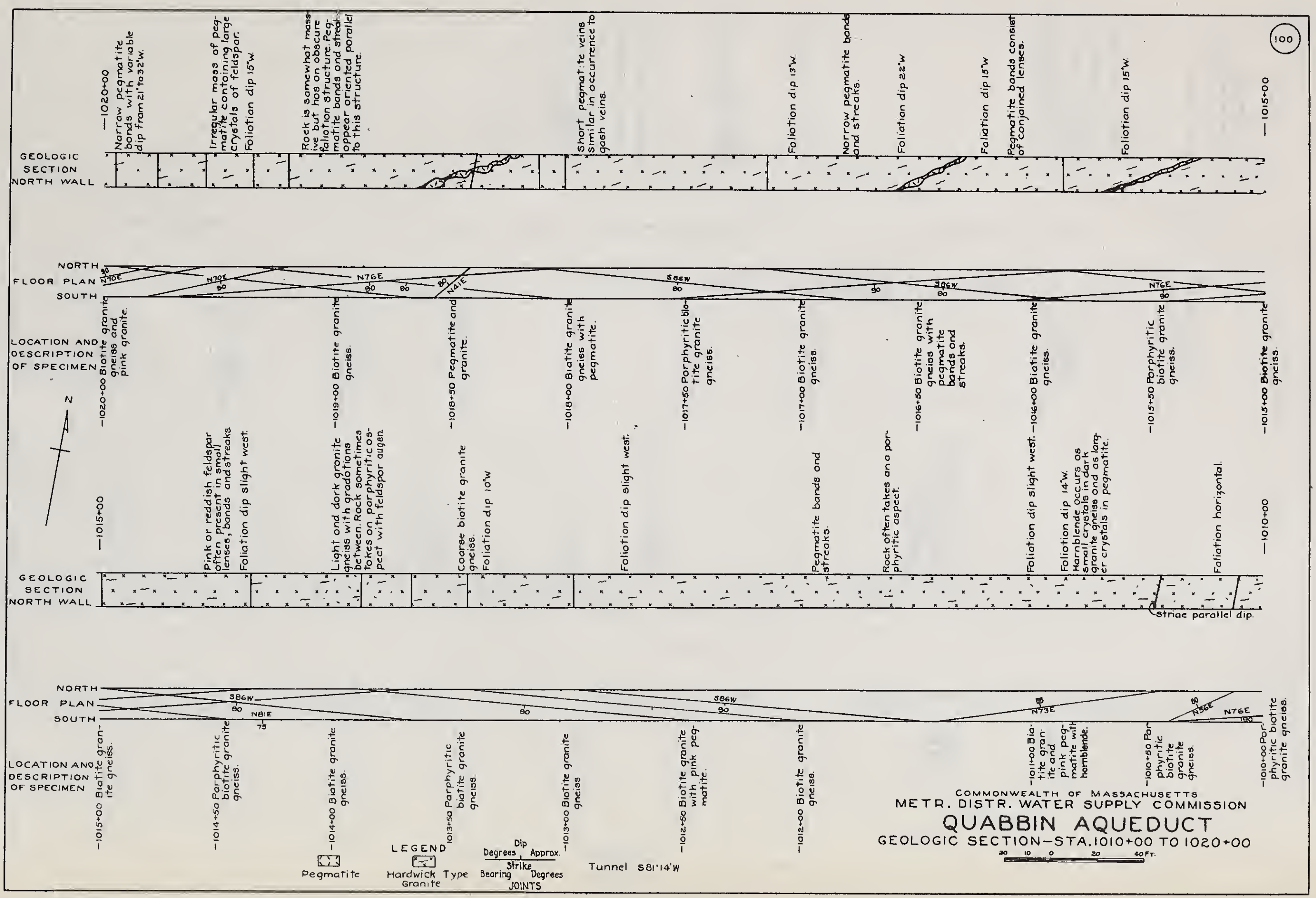

GEOLOGIC SECTION NORTH WALL
—990+00
Narrow pegmatite bands
Foliation dip 12°W.
2" pegmatite band.
— SHAFT 10
Foliation slight west dip
Gneiss contains pink or reddish feldspar crystal lenses.
Small (1"-2") pegmatite lenses occur in groups. Also in bands.
Foliation Strike N0°E. Dip 8°W
Hard black biotite porphyritic granite Most of rock composed of black biotite and possibly other dark minerals, together with quartz and larger crystals of feldspar. Individual crystals and groups of feldspar crystals occur as well.
Structure through here is somewhat massive
Foliation dip slightly west
Pegmatite streaks and bands
Section through here largely made up of porphyritic dark granite or gneiss.
Pegmatite in small folds
Foliation dip 7°W
Dark biotite granite gneiss
About 5% pegmatite in lenses, streaks and bands
Foliation dip 4°W
—985+00
Gunite Protective Coating
NORTH
FLOOR PLAN
SOUTH
80 N61E
80 N61E
75 N61E
80 N66E
80 N46E
LOCATION AND DESCRIPTION OF SPECIMEN
—990+00 Dark biotite granite gneiss.
—989+50 Dark biotite granite gneiss.
—989+00 Dark biotite granite gneiss
—988+50 Dark biotite granite gneiss.
—988+00 Dark biotite granite gneiss.
—987+50 Dark biotite granite gneiss.
—987+00 Dark biotite granite gneiss
—986+50 Foliated biotite granite.
—986+00 Biotite granite with pink pegmatite lenses
—985+50 Biotite granite gneiss
—985+00 Porphyritic biotite granite
N
—985+00
Pink pegmatite bands
Foliation 10°W
Several foliation joints at five-foot intervals.
Foliation dip 42°W
Foliation dip 8°W
Massive biotite granite gneiss
Bands of much lighter granite.
Foliation dip 22°W
Gneissoid granite. Pegmatite in form of streaks, bands, etc., occurs as large part of rock.
Foliation slight west dip
—980+00
GEOLOGIC SECTION NORTH WALL
Cracks which parallel foliation structure are essentially joints.
Minor fractures at right angles to foliation. Strike N0°E
NORTH
FLOOR PLAN
SOUTH
75
75 N46E
75 N46E
80 N31E
N0E 45
N35E 45
80 N35E
N31E 75
LOCATION AND DESCRIPTION OF SPECIMEN
—985+00 Porphyritic biotite granite
—984+50 Porphyritic biotite granite Pink pegmatite
—984+00 Biotite schist
—983+50 Biotite granite gneiss
—983+00 Porphyritic biotite granite.
—982+50 Foliated biotite granite with pegmatite streaks
—982+00 Biotite granite gneiss
—981+50 Gray granite
—981+00 Biotite granite with pegmatite
—980+50 Biotite granite gneiss
—980+00 Gray granite
LEGEND
Pegmatite
Hardwick Type Granite
Dip Degrees, Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 980+00 TO 990+00

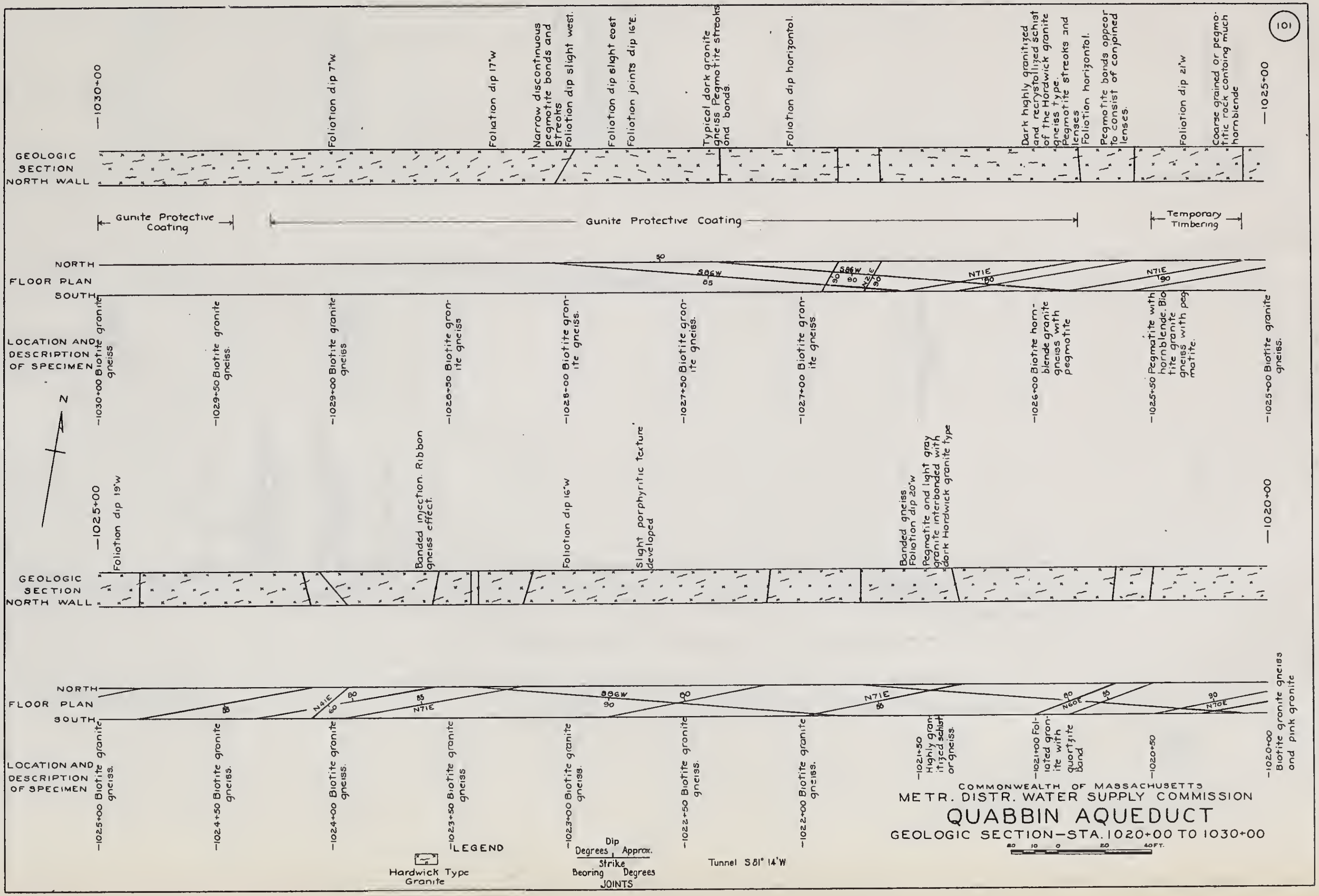


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 990+00 TO 1000+00

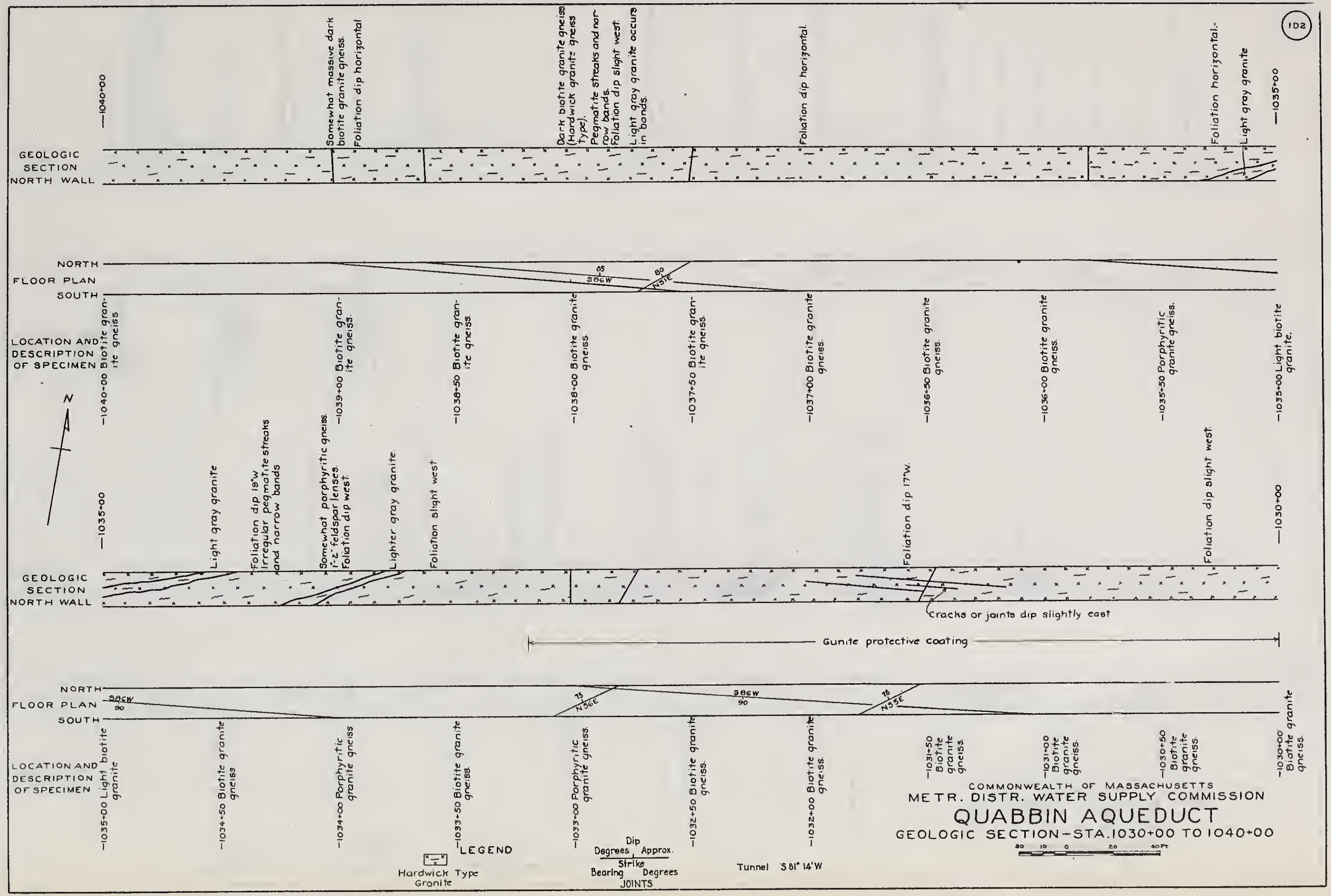
GEOLOGIC SECTION NORTH WALL
1000+00
Constant low westerly dip.
Streaked gneissoid granite
Foliation dip 18°W.
Narrow bands of dark biotite quartz schist between coarse gneissoid granite
Foliation dip 6°W
Foliation dip 26°W.
995+00
Several joints (strike N1°E, dip 70°E) occur at right angles to foliation structure
NORTH
FLOOR PLAN
SOUTH
N40E 80
N40E 80
N56E 80
N32E 80
N36E 22
N81E 80
N32E
N81E 70
N36E 80
80
N36E 75
LOCATION AND DESCRIPTION OF SPECIMEN
1000+00 Granitized biotite schist.
999+50 Gneissoid biotite pegmatitic granite.
999+00 Pegmatitic biotite granite.
998+50 Biotite gneissoid granite
998+00 Biotite gneissoid granite
997+50 Biotite gneissoid granite
997+00 Biotite gneissoid granite.
996+50 Pegmatitic biotite granite
996+00 Biotite granite gneiss
995+50 Biotite granite gneiss.
995+00 Biotite granite gneiss.
N
995+00
Small irregular areas of pegmatite
Pegmatite banding and streaking
Foliation dip 28°W
Pegmatite bands occur in widths ranging from a fraction of an inch to 12 inches
Foliation dip 30°W. Abrupt termination of some pegmatite bands and truncation of some small folds indicates slight displacement of west side downward
Foliation dip 20°W
Patches of lighter, less biotitic granite
Foliation dip 26°W
Ribbon gneiss formed by broad and narrow bands of pegmatite
Largely light pegmatitic granite containing bands and streaks of darker granite or granitized schist.
Normal biotite granite gneiss.
Foliation dip 11°W.
Dark coarse biotite granite
Pink or red pegmatite in small lenses and bands
Foliation dip 12°W
Pegmatite bands and streaks Pegmatite lies parallel to and across foliation.
Foliation horizontal.
Contorted pegmatite band.
990+00
GEOLOGIC SECTION NORTH WALL
Intense banded injection
Open foliation.
Gunite Protective Coating
NORTH
FLOOR PLAN
SOUTH
N36E 75
N36E 70
LOCATION AND DESCRIPTION OF SPECIMEN
995+00 Biotite granite gneiss.
994+50 Banded biotite granite gneiss.
994+00 Pegmatite
993+00 Biotite granite gneiss
992+50 Biotite granite gneiss and pegmatite.
992+00 Pegmatite.
991+50 Biotite granite gneiss with pink feldspar nodules and streaks
991+00 Pink pegmatite with biotite border.
990+50 Dark biotite granite gneiss.
990+00 Dark biotite granite gneiss.
LEGEND
Pegmatite
Hardwick Type Granite
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40 FT.


100
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
—1020+00
Narrow pegmatite bands with variable dip from 21° to 32°W.
Irregular mass of pegmatite containing large crystals of feldspar.
Foliation dip 15°W.
Rock is somewhat massive but has an obscure foliation structure. Pegmatite bands and streaks appear oriented parallel to this structure.
Short pegmatite veins similar in occurrence to gash veins.
Foliation dip 13°W.
Narrow pegmatite bands and streaks.
Foliation dip 22°W.
Foliation dip 15°W
Pegmatite bands consist of conjoined lenses.
Foliation dip 15°W.
—1015+00
N70E
N76E
N41E
S86W
N76E
90
80
—1020+00 Biotite granite gneiss and pink granite.
—1019+00 Biotite granite gneiss.
—1018+50 Pegmatite and granite.
—1018+00 Biotite granite gneiss with pegmatite.
—1017+50 Porphyritic biotite granite gneiss.
—1017+00 Biotite granite gneiss.
—1016+50 Biotite granite gneiss with pegmatite bands and streaks.
—1016+00 Biotite granite gneiss.
—1015+50 Porphyritic biotite granite gneiss.
—1015+00 Biotite granite gneiss.
N
—1015+00
Pink or reddish feldspar often present in small lenses, bands and streaks
Foliation dip slight west.
Light and dark granite gneiss with gradations between. Rock sometimes takes on porphyritic aspect with feldspar augen.
Coarse biotite granite gneiss.
Foliation dip 10°W
Foliation dip slight west.
Pegmatite bands and streaks.
Rock often takes on a porphyritic aspect.
Foliation dip slight west.
Foliation dip 14°W.
Hornblende occurs as small crystals in dark granite gneiss and as larger crystals in pegmatite.
Foliation horizontal.
—1010+00
Striae parallel dip.
S86W
N81E
75
N73E
N56E
N76E
—1015+00 Biotite granite gneiss.
—1014+50 Porphyritic biotite granite gneiss.
—1014+00 Biotite granite gneiss.
—1013+50 Porphyritic biotite granite gneiss.
—1013+00 Biotite granite gneiss
—1012+50 Biotite granite with pink pegmatite.
—1012+00 Biotite granite gneiss.
—1011+00 Biotite granite and pink pegmatite with hornblende.
—1010+50 Porphyritic biotite granite gneiss.
—1010+00 Porphyritic biotite granite gneiss.
LEGEND
Pegmatite
Hardwick Type Granite
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S81°14'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 1010+00 TO 1020+00


101
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
—1030+00
—1025+00
—1020+00
Foliation dip 7°W
Foliation dip 17°W
Narrow discontinuous pegmatite bands and streaks
Foliation dip slight west.
Foliation dip slight east
Foliation joints dip 16°E.
Typical dark granite gneiss Pegmatite streaks and bands.
Foliation dip horizontal.
Dark highly granitized and recrystallized schist of the Hardwick granite gneiss type.
Pegmatite streaks and lenses
Foliation horizontal.
Pegmatite bands appear to consist of conjoined lenses.
Foliation dip 21°W
Coarse grained or pegmatitic rock containg much hornblende
Gunite Protective Coating
Gunite Protective Coating
Temporary Timbering
S86W 65
S86W 90
N4E 90
N7IE 80
N7IE 90
50
90
-1030+00 Biotite granite gneiss
-1029+50 Biotite granite gneiss.
-1029+00 Biotite granite gneiss
-1028+50 Biotite granite gneiss
-1028+00 Biotite granite gneiss.
-1027+50 Biotite granite gneiss.
-1027+00 Biotite granite gneiss
-1026+00 Biotite hornblende granite gneiss with pegmatite
-1025+50 Pegmatite with hornblende. Biotite granite gneiss with pegmatite.
-1025+00 Biotite granite gneiss.
N
Foliation dip 19°W
Banded injection. Ribbon gneiss effect.
Foliation dip 16°W
Slight porphyritic texture developed
Banded gneiss
Foliation dip 20°W
Pegmatite and light gray granite interbanded with dark Hardwick granite type
N4IE 60
80
85
N7IE
S86W 90
N7IE 85
80
N60E
90
N70E
-1025+00 Biotite granite gneiss.
-1024+50 Biotite granite gneiss.
-1024+00 Biotite granite gneiss.
-1023+50 Biotite granite gneiss
-1023+00 Biotite granite gneiss.
-1022+50 Biotite granite gneiss.
-1022+00 Biotite granite gneiss.
-1021+50 Highly granitized schist or gneiss.
-1021+00 Foliated granite with quartzite band
-1020+50
-1020+00 Biotite granite gneiss and pink granite
LEGEND
Hardwick Type Granite
Dip Degrees Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S81° 14'W
80 10 0 20 40FT.

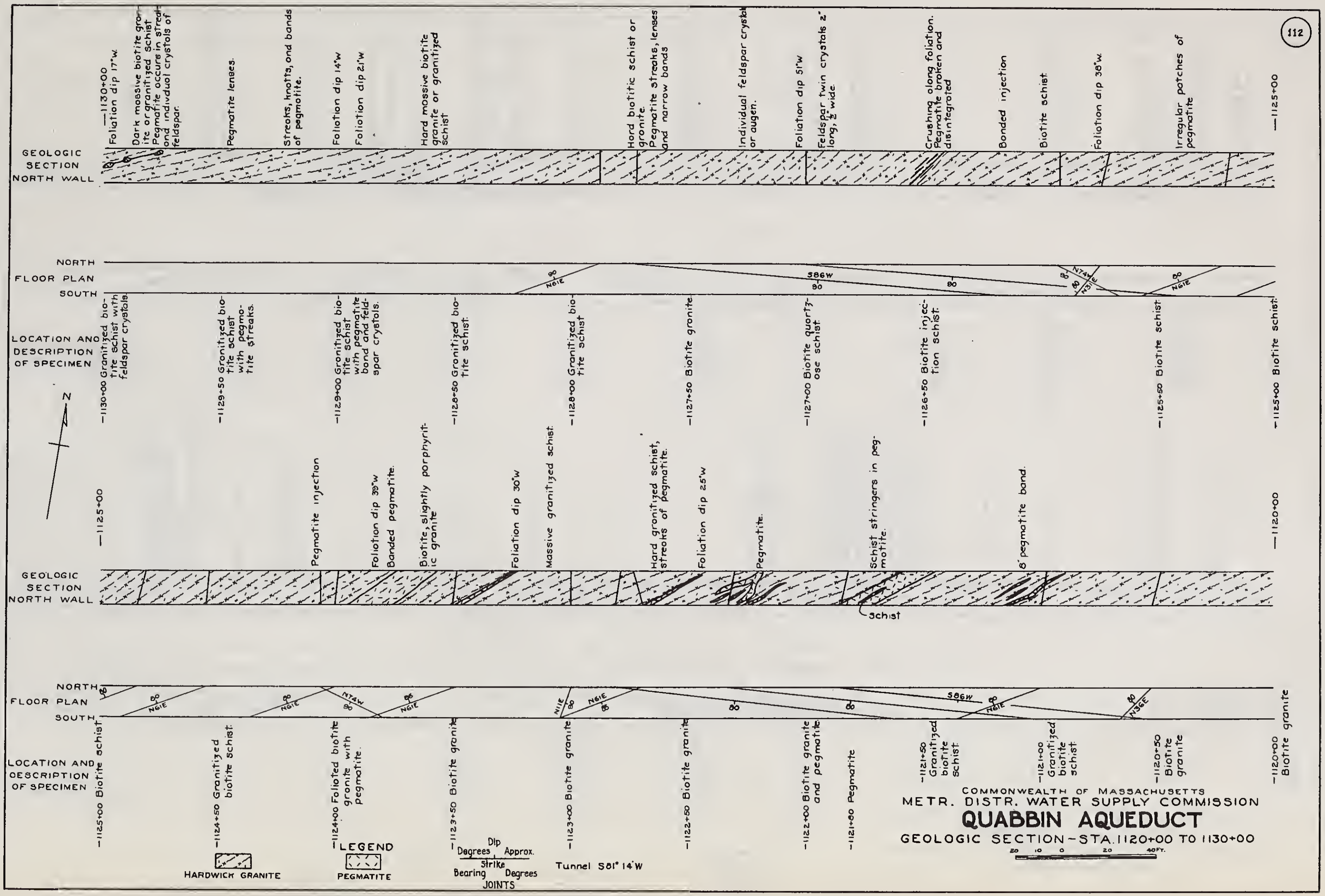
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 1020+00 TO 1030+00


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION—STA. 1030+00 TO 1040+00

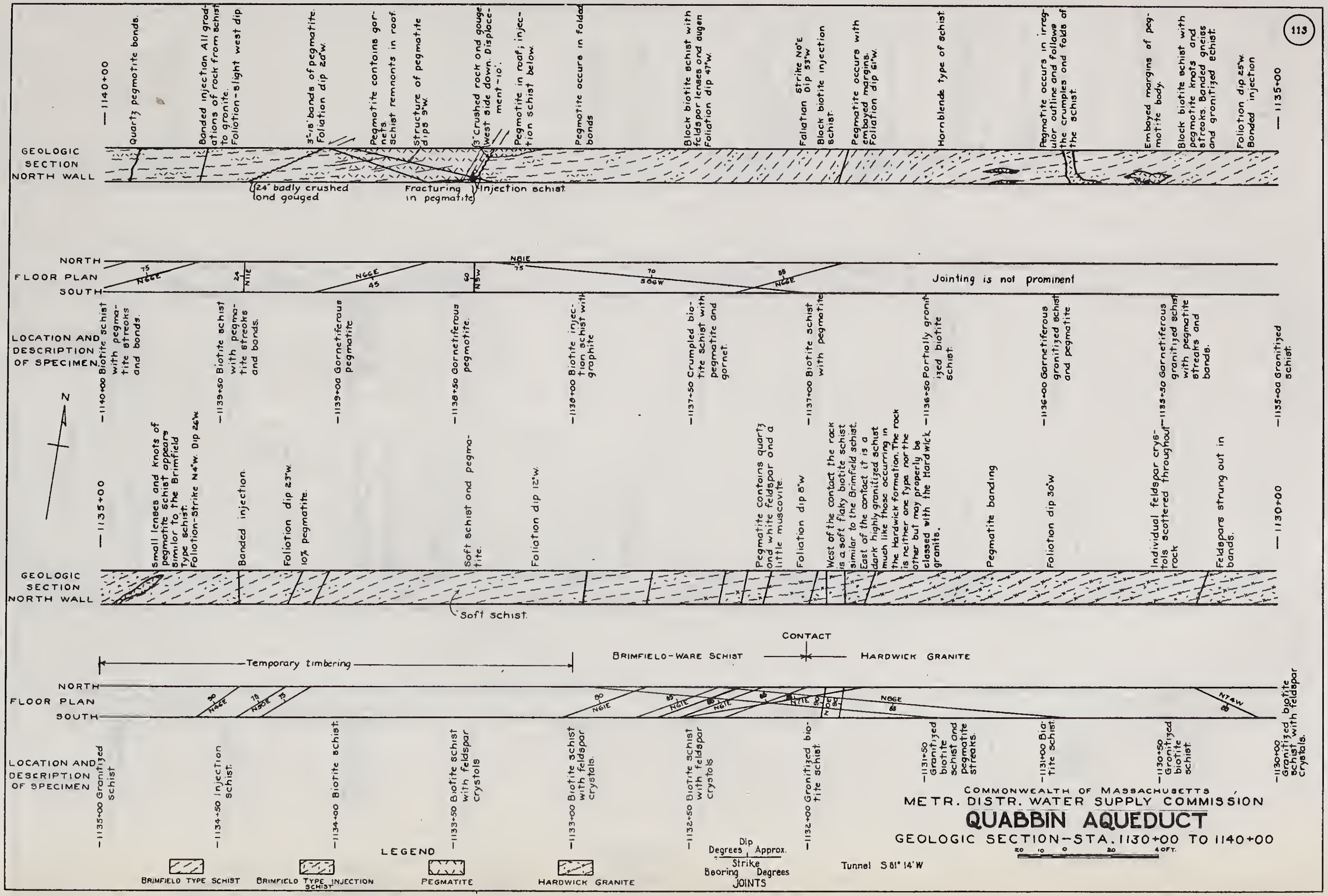
102
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
—1040+00
—1035+00
—1030+00
Somewhat massive dark biotite granite gneiss.
Foliation dip horizontal
Dark biotite granite gneiss (Hardwick granite gneiss type).
Pegmatite streaks and narrow bands.
Foliation dip slight west.
Light gray granite occurs in bands.
Foliation dip horizontal.
Foliation horizontal.-
Light gray granite
65
S86W
80
N51E
—1040+00 Biotite granite gneiss
—1039+00 Biotite granite gneiss.
—1038+50 Biotite granite gneiss.
—1038+00 Biotite granite gneiss.
—1037+50 Biotite granite gneiss.
—1037+00 Biotite granite gneiss.
—1036+50 Biotite granite gneiss.
—1036+00 Biotite granite gneiss.
—1035+50 Porphyritic granite gneiss.
—1035+00 Light biotite granite.
N
Light gray granite.
Foliation dip 19°W
Irregular pegmatite streaks and narrow bands
Somewhat porphyritic gneiss.
1"-2" feldspar lenses.
Foliation dip west.
Lighter gray granite.
Foliation slight west
Foliation dip 17°W.
Foliation dip slight west.
Cracks or joints dip slightly east
Gunite protective coating
S86W
90
75
N56E
S86W
90
75
N55E
—1035+00 Light biotite granite
—1034+50 Biotite granite gneiss
—1034+00 Porphyritic granite gneiss
—1033+50 Biotite granite gneiss
—1033+00 Porphyritic granite gneiss.
—1032+50 Biotite granite gneiss.
—1032+00 Biotite granite gneiss.
—1031+50 Biotite granite gneiss.
—1031+00 Biotite granite gneiss.
—1030+50 Biotite granite gneiss.
—1030+00 Biotite granite gneiss.
LEGEND
Hardwick Type Granite
Dip
Degrees Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S 61° 14' W
20 10 0 20 40 Ft

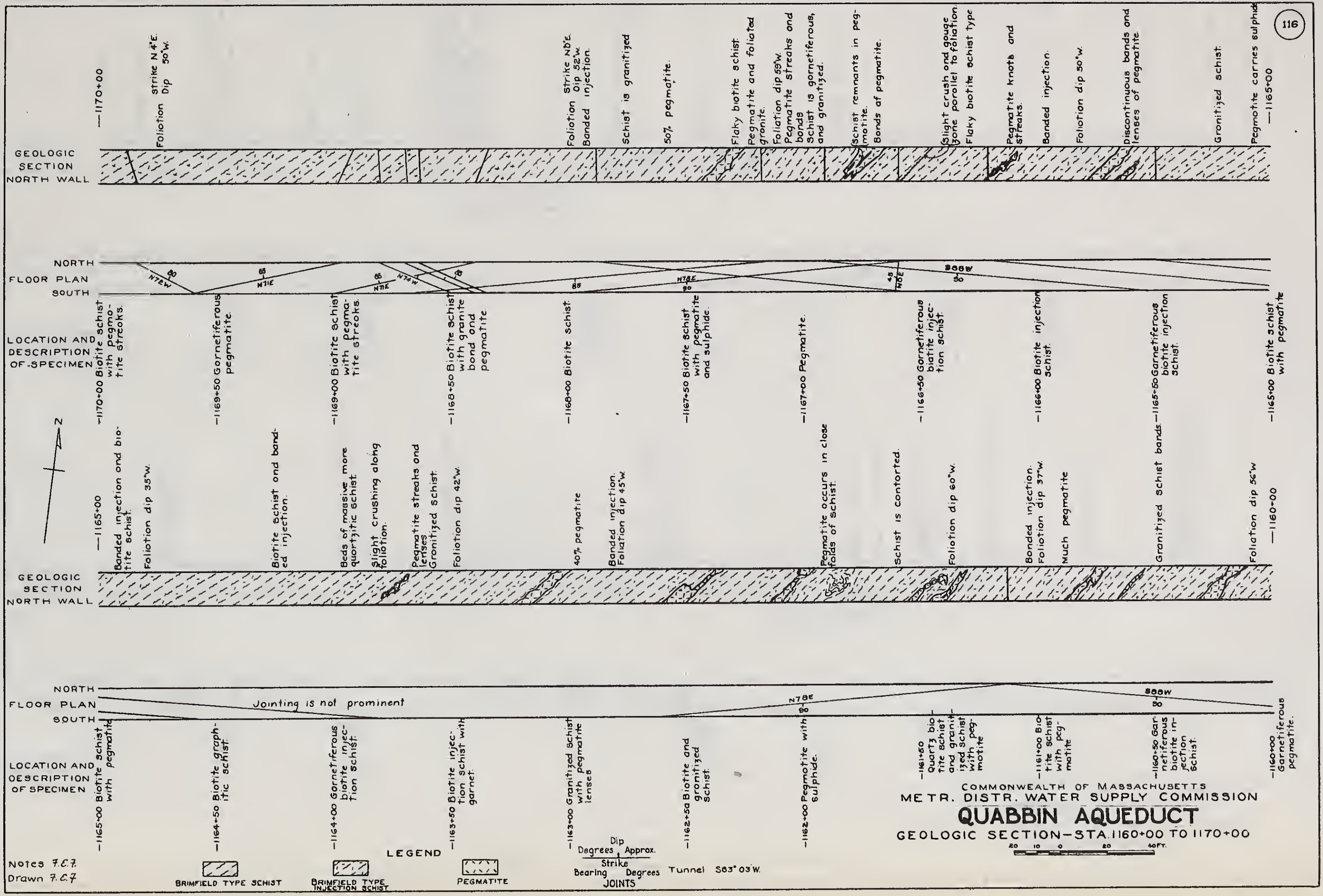

GEOLOGIC SECTION NORTH WALL
—1130+00
Foliation dip 17°W.
Dark massive biotite granite or granitized schist Pegmatite occurs in streaks and individual crystals of feldspar.
Pegmatite lenses.
Streaks, knotts, and bands of pegmatite.
Foliation dip 14°W
Foliation dip 21°W
Hard massive biotite granite or granitized schist
Hard biotitic schist or granite.
Pegmatite streaks, lenses and narrow bands
Individual feldspar crystals or augen.
Foliation dip 51°W
Feldspar twin crystals 2" long, ½" wide.
Crushing along foliation. Pegmatite broken and disintegrated
Banded injection
Biotite schist.
Foliation dip 38°W.
Irregular patches of pegmatite
—1125+00
NORTH
FLOOR PLAN
SOUTH
N61E
80
S86W
90
80
N74W
N31E
N61E
LOCATION AND DESCRIPTION OF SPECIMEN
—1130+00 Granitized biotite schist with feldspar crystals.
—1129+50 Granitized biotite schist with pegmatite streaks.
—1129+00 Granitized biotite schist with pegmatite band and feldspar crystals.
—1128+50 Granitized biotite schist.
—1128+00 Granitized biotite schist
—1127+50 Biotite granite.
—1127+00 Biotite quartzose schist
—1126+50 Biotite injection schist.
—1125+50 Biotite schist.
—1125+00 Biotite schist.
N
GEOLOGIC SECTION NORTH WALL
—1125+00
Pegmatite injection
Foliation dip 39°W
Banded pegmatite.
Biotite, slightly porphyritic granite
Foliation dip 30°W
Massive granitized schist.
Hard granitized schist, streaks of pegmatite.
Foliation dip 25°W
Pegmatite.
Schist stringers in pegmatite.
Schist
8' pegmatite band.
—1120+00
NORTH
FLOOR PLAN
SOUTH
80
N61E
N74W
N11E
S86W
N36E
LOCATION AND DESCRIPTION OF SPECIMEN
—1125+00 Biotite schist
—1124+50 Granitized biotite schist.
—1124+00 Foliated biotite granite with pegmatite.
—1123+50 Biotite granite
—1123+00 Biotite granite
—1122+50 Biotite granite
—1122+00 Biotite granite and pegmatite
—1121+80 Pegmatite
—1121+50 Granitized biotite schist
—1121+00 Granitized biotite schist.
—1120+50 Biotite granite
—1120+00 Biotite granite
LEGEND
HARDWICK GRANITE
PEGMATITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S81° 14'W
20 10 0 20 40FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

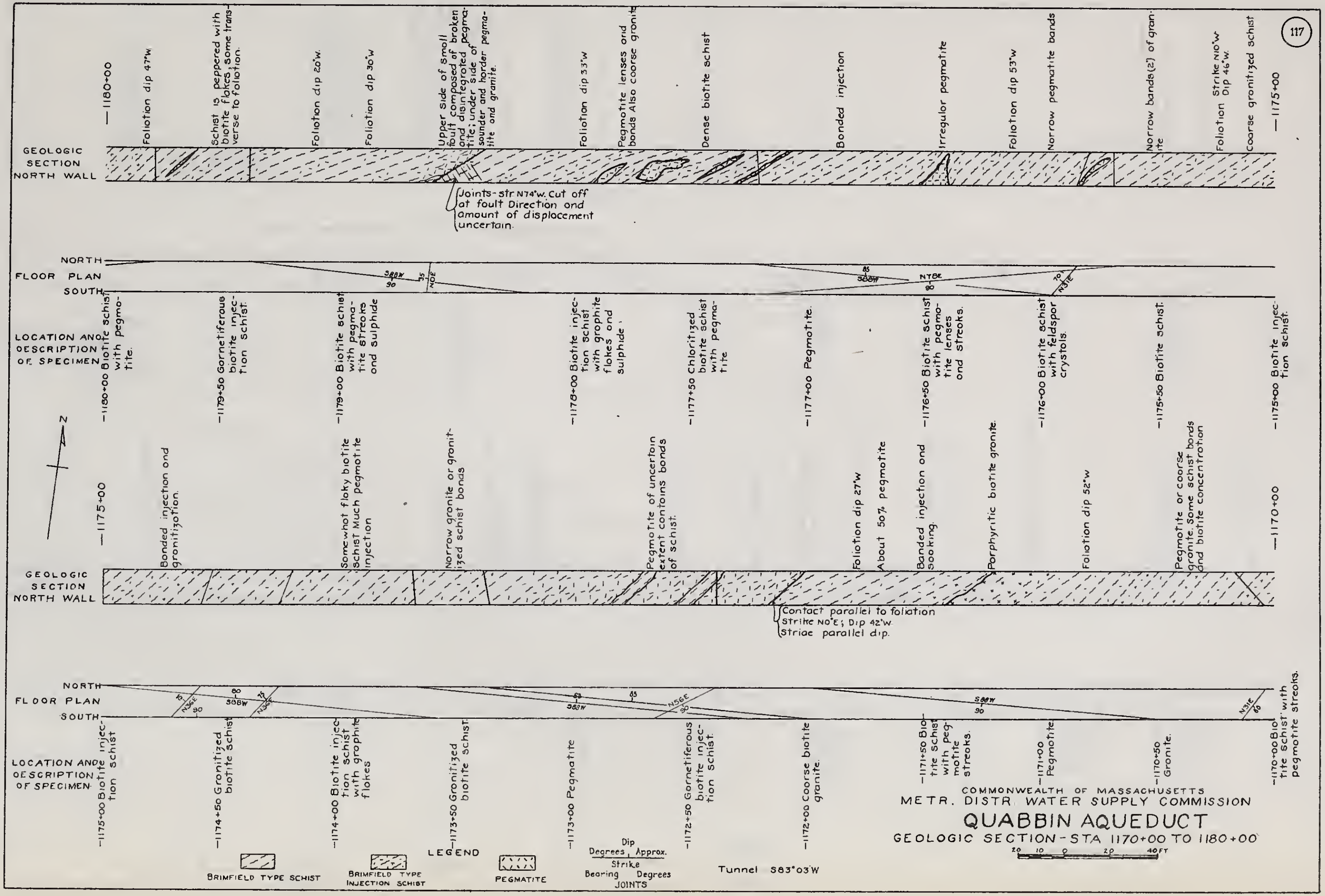
QUABBIN AQUEDUCT

GEOLOGIC SECTION – STA. 1120+00 TO 1130+00


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 1130+00 TO 1140+00
20 10 0 20 40FT.
Tunnel S 81° 14' W
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
N
1140+00
Quartz pegmatite bands.
Banded injection All gradations of rock from schist to granite. Foliation-slight west dip
3"-18" bands of pegmatite. Foliation dip 20°W.
Pegmatite contains garnets. Schist remnants in roof.
Structure of pegmatite dips 9°W.
3' Crushed rock and gouge west side down. Displacement-10'.
Pegmatite in roof; injection schist below.
Pegmatite occurs in folded bands
Block biotite schist with feldspar lenses and augen Foliation dip 47°W.
Foliation Strike N0°E Dip 53°W
Block biotite injection schist.
Pegmatite occurs with embayed margins. Foliation dip 61°W.
Hornblende type of schist.
Pegmatite occurs in irregular outline and follows the crumples and folds of the schist.
Embayed margins of pegmatite body.
Block biotite schist with pegmatite knots and streaks. Banded gneiss and granitized schist.
Foliation dip 25°W. Banded injection
1135+00
24" badly crushed and gouged
Fracturing in pegmatite
Injection schist
75 N66E
24 N11E
N66E 45
3 N3W
N81E 75
70 S66W
85 N66E
Jointing is not prominent
1140+00 Biotite schist with pegmatite streaks and bands.
1139+50 Biotite schist with pegmatite streaks and bands.
1139+00 Garnetiferous pegmatite
1138+50 Garnetiferous pegmatite.
1138+00 Biotite injection schist with graphite
1137+50 Crumpled biotite schist with pegmatite and garnet.
1137+00 Biotite schist with pegmatite
1136+50 Partially granitized biotite schist
1136+00 Garnetiferous granitized schist and pegmatite
1135+50 Garnetiferous granitized schist with pegmatite streaks and bands.
1135+00 Granitized schist.
1135+00
Small lenses and knots of pegmatite schist appears similar to the Brimfield Type schist. Foliation-Strike N4°W. Dip 26°W.
Banded injection.
Foliation dip 23°W.
10% pegmatite.
Soft schist and pegmatite.
Foliation dip 12°W.
Pegmatite contains quartz and white feldspar and a little muscovite.
Foliation dip 5°W
West of the contact the rock is a soft flaky biotite schist similar to the Brimfield schist. East of the contact it is a dark highly granitized schist much like those occurring in the Hardwick formation. The rock is neither one type nor the other but may properly be classed with the Hardwick granite.
Pegmatite banding
Foliation dip 30°W
Individual feldspar crystals scattered throughout rock
Feldspars strung out in bands.
1130+00
Soft schist.
Temporary timbering
BRIMFIELD-WARE SCHIST
CONTACT
HARDWICK GRANITE
30 N42E
75 N50E 75
80 N61E
85 N61E
85 N61E
N71E
N66E 65
N74W 85
1135+00 Granitized schist
1134+50 Injection schist.
1134+00 Biotite schist.
1133+50 Biotite schist with feldspar crystals
1133+00 Biotite schist with feldspar crystals.
1132+50 Biotite schist with feldspar crystals
1132+00 Granitized biotite schist.
1131+50 Granitized biotite schist and pegmatite streaks.
1131+00 Biotite schist.
1130+50 Granitized biotite schist.
1130+00 Granitized biotite schist with feldspar crystals.
LEGEND
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PEGMATITE
HARDWICK GRANITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS



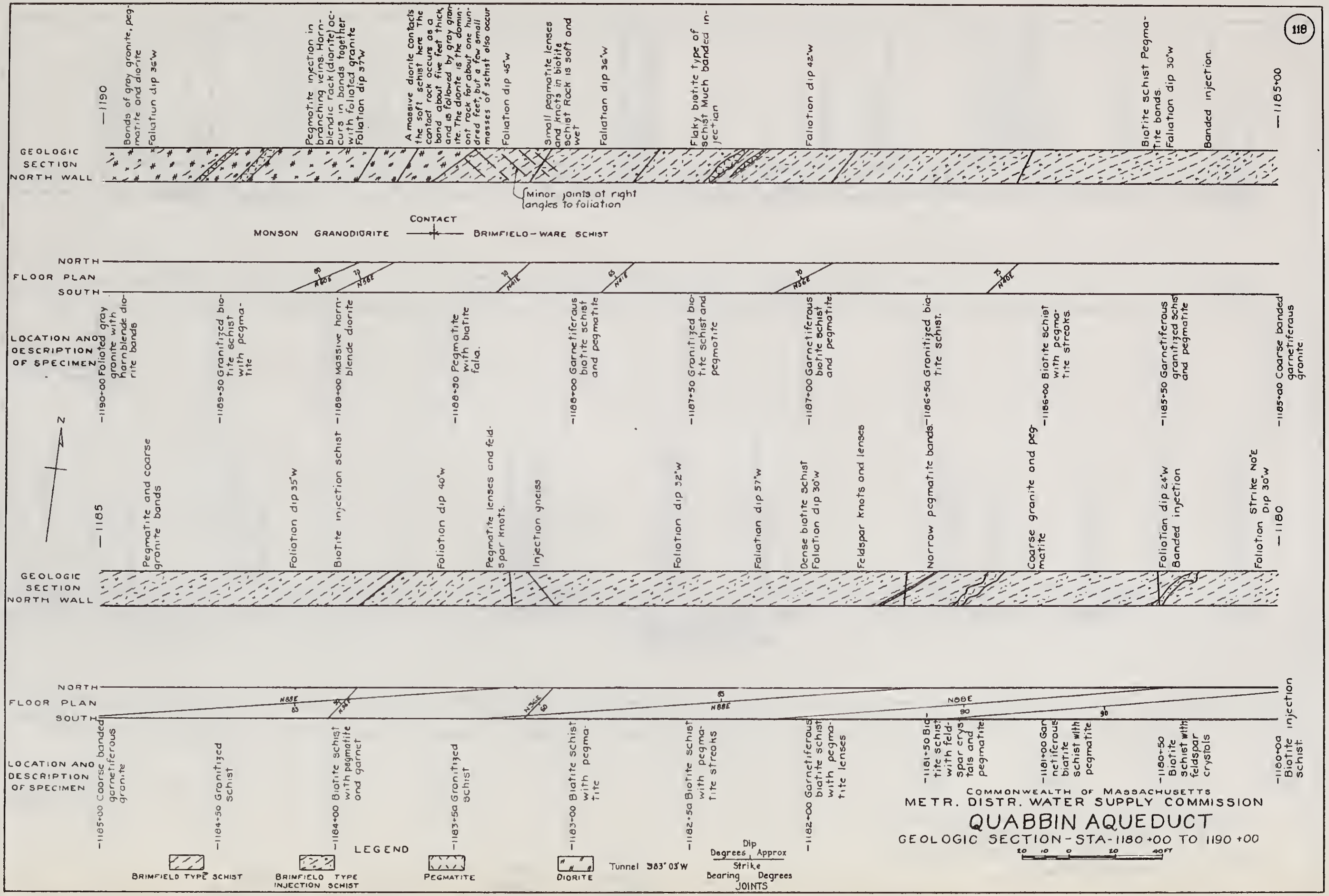
GEOLOGIC SECTION NORTH WALL
—1170+00
Foliation strike N4°E. Dip 50°W.
Foliation Strike N8°E. Dip 52°W. Banded injection.
Schist is granitized
50% pegmatite.
Flaky biotite schist
Pegmatite and foliated granite.
Foliation dip 59°W. Pegmatite streaks and bands Schist is garnetiferous, and granitized.
Schist remnants in pegmatite. Bands of pegmatite.
Slight crush and gouge zone parallel to foliation. Flaky biotite schist type
Pegmatite knots and streaks.
Banded injection.
Foliation dip 50°W.
Discontinuous bands and lenses of pegmatite
Granitized schist.
Pegmatite carries sulphide
—1165+00
NORTH FLOOR PLAN SOUTH
N72W 80
N71E 85
N71E 85
N74W
85
85
N78E 90
45 N10E
S88W 90
LOCATION AND DESCRIPTION OF SPECIMEN
—1170+00 Biotite schist with pegmatite streaks.
—1169+50 Garnetiferous pegmatite.
—1169+00 Biotite schist with pegmatite streaks.
—1168+50 Biotite schist with granite band and pegmatite
—1168+00 Biotite schist.
—1167+50 Biotite schist with pegmatite and sulphide.
—1167+00 Pegmatite.
—1166+50 Garnetiferous biotite injection schist.
—1166+00 Biotite injection schist.
—1165+50 Garnetiferous biotite injection schist.
—1165+00 Biotite schist with pegmatite
N
—1165+00
Banded injection and biotite schist.
Foliation dip 35°W.
Biotite schist and banded injection.
Beds of massive more quartzitic schist.
Slight crushing along foliation.
Pegmatite streaks and lenses Granitized schist.
Foliation dip 42°W.
40% pegmatite
Banded injection. Foliation dip 45°W.
Pegmatite occurs in close folds of schist.
Schist is contorted.
Foliation dip 60°W.
Banded injection. Foliation dip 37°W.
Much pegmatite
Granitized schist bands.
Foliation dip 56°W
—1160+00
GEOLOGIC SECTION NORTH WALL
NORTH FLOOR PLAN SOUTH
Jointing is not prominent
N78E 90
S88W 50
LOCATION AND DESCRIPTION OF SPECIMEN
—1165+00 Biotite schist with pegmatite
—1164+50 Biotite graphitic schist.
—1164+00 Garnetiferous biotite injection schist.
—1163+50 Biotite injection schist with garnet.
—1163+00 Granitized schist with pegmatite lenses
—1162+50 Biotite and granitized schist.
—1162+00 Pegmatite with sulphide.
—1161+50 Quartz biotite schist and granitized schist with pegmatite.
—1161+00 Biotite schist with pegmatite
—1160+50 Garnetiferous biotite injection schist.
—1160+00 Garnetiferous pegmatite.
Notes F.C.F.
Drawn F.C.F.
LEGEND
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PEGMATITE
Dip Degrees Approx.
Strike Bearing Degrees
JOINTS
Tunnel S63° 03'W.
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA.1160+00 TO 1170+00
20 10 0 20 40FT.


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION - STA 1170+00 TO 1180+00

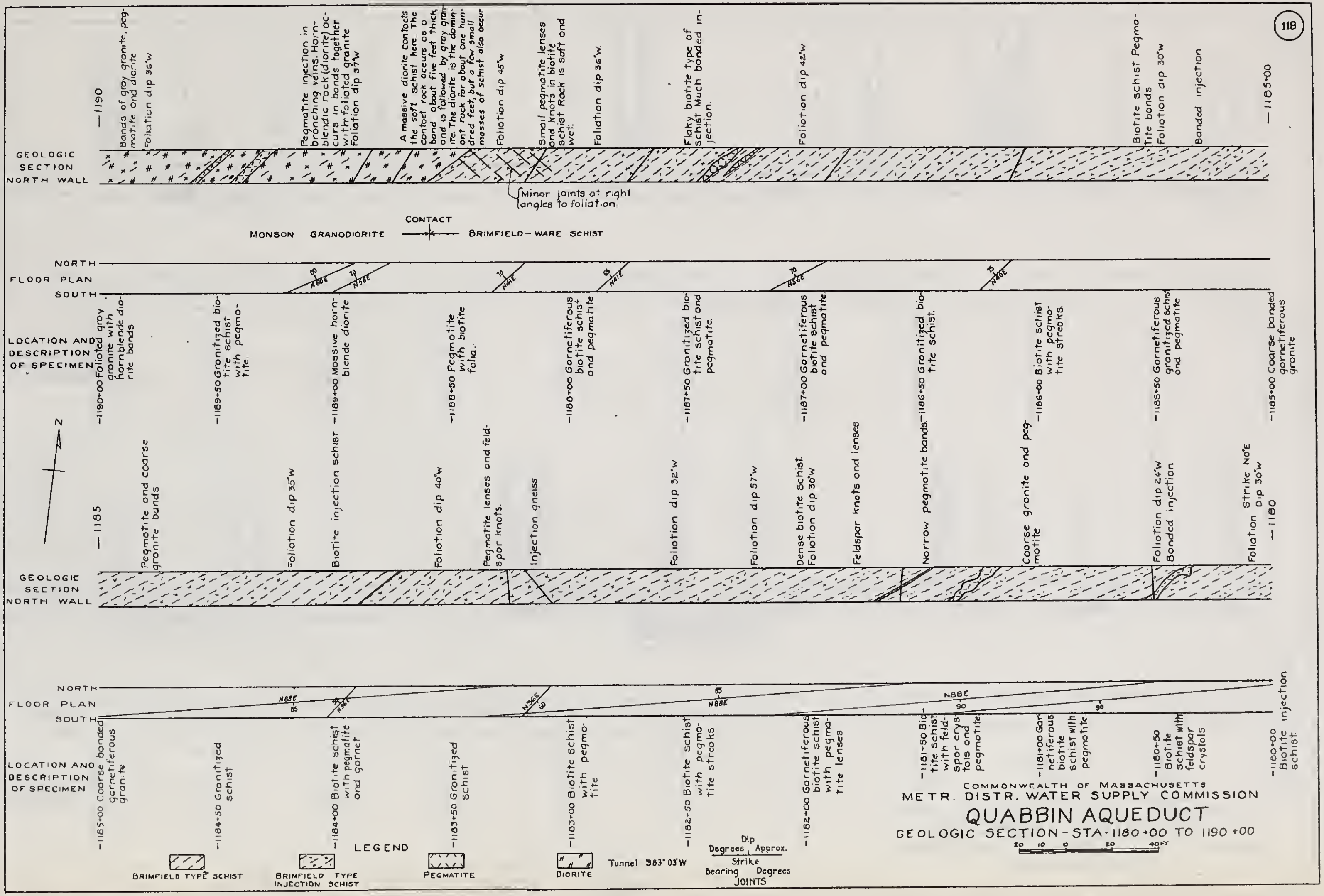
117
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
1180+00
Foliation dip 47°W.
Schist is peppered with biotite flakes, some transverse to foliation.
Foliation dip 20°W.
Foliation dip 30°W
Upper side of small fault composed of broken and disintegrated pegmatite; under side of sounder and harder pegmatite and granite.
Joints-str N74°W. Cut off at fault Direction and amount of displacement uncertain.
Foliation dip 33°W
Pegmatite lenses and bands Also coarse granite
Dense biotite schist
Banded injection
Irregular pegmatite
Foliation dip 53°W
Narrow pegmatite bands
Narrow bands(?) of granite
Foliation Strike N10°W Dip 46°W.
Coarse granitized schist
1175+00
S88W
90
35
N0E
85
S88W
N78E
80
70
N31E
1180+00 Biotite schist with pegmatite.
1179+50 Garnetiferous biotite injection schist.
1179+00 Biotite schist with pegmatite streaks and sulphide
1178+00 Biotite injection schist with graphite flakes and sulphide.
1177+50 Chloritized biotite schist with pegmatite
1177+00 Pegmatite.
1176+50 Biotite schist with pegmatite lenses and streaks.
1176+00 Biotite schist with feldspar crystals.
1175+50 Biotite schist.
1175+00 Biotite injection schist.
N
1175+00
Banded injection and granitization.
Somewhat flaky biotite schist Much pegmatite injection
Narrow granite or granitized schist bands
Pegmatite of uncertain extent contains bands of schist.
Contact parallel to foliation Strike N0°E; Dip 42°W. Striae parallel dip.
Foliation dip 27°W
About 50% pegmatite
Banded injection and soaking.
Porphyritic biotite granite.
Foliation dip 52°W
Pegmatite or coarse granite. Some schist bands and biotite concentration
1170+00
75
N36E
90
80
S88W
75
N36E
63
S83W
85
N56E
90
S88W
90
N31E
80
1175+00 Biotite injection schist
1174+50 Granitized biotite schist
1174+00 Biotite injection schist with graphite flakes
1173+50 Granitized biotite schist.
1173+00 Pegmatite
1172+50 Garnetiferous biotite injection schist.
1172+00 Coarse biotite granite.
1171+50 Biotite schist with pegmatite streaks.
1171+00 Pegmatite.
1170+50 Granite.
1170+00 Biotite schist with pegmatite streaks.
LEGEND
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PEGMATITE
Dip Degrees, Approx.
Strike Bearing Degrees
JOINTS
Tunnel S83°03'W
20 10 0 20 40FT

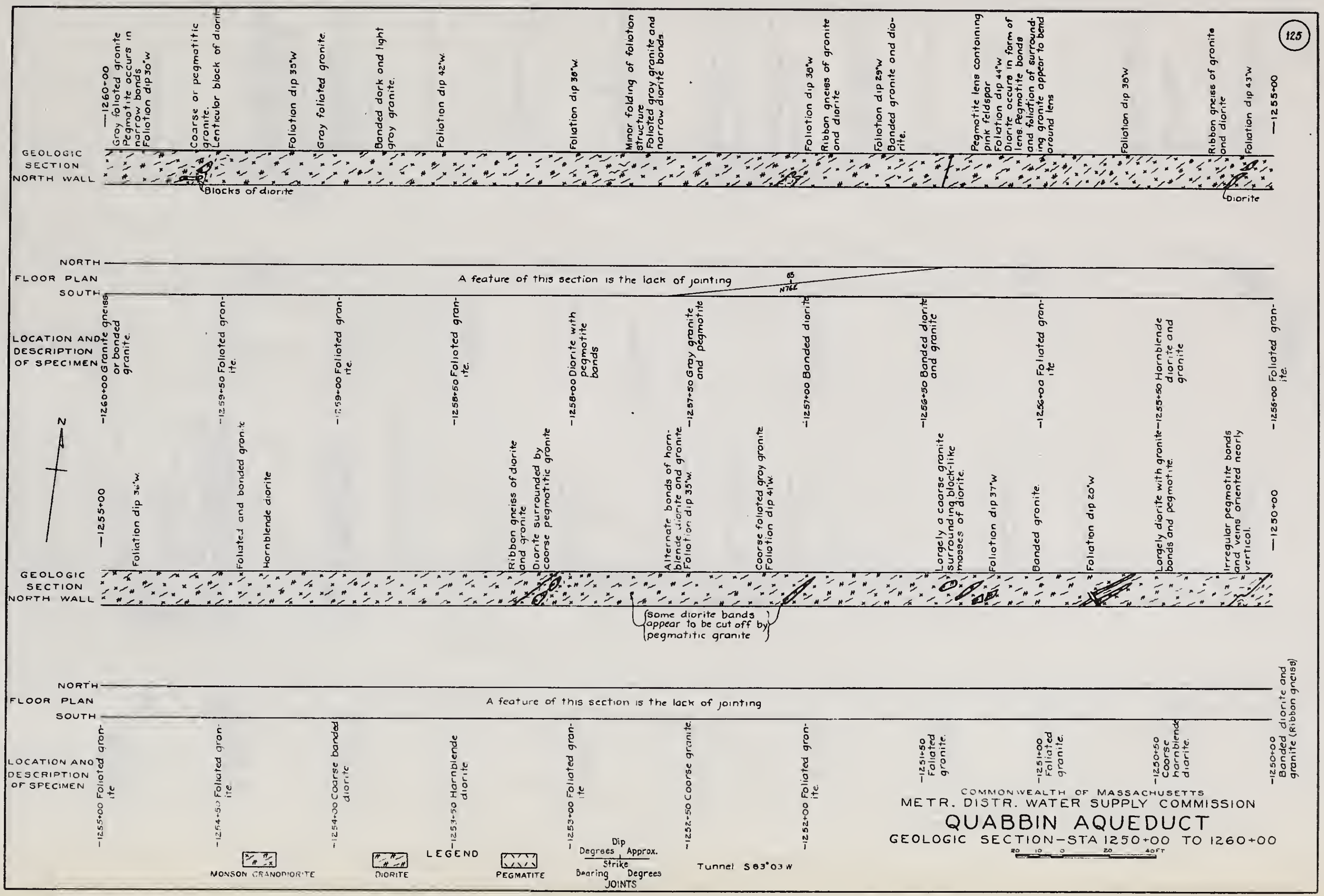

GEOLOGIC SECTION NORTH WALL
—1190
Bands of gray granite, pegmatite and diorite
Foliation dip 36°W
Pegmatite injection in branching veins. Hornblendic rock (diorite) occurs in bands together with foliated granite Foliation dip 37°W
A massive diorite contacts the soft schist here The contact rock occurs as a band about five feet thick and is followed by gray granite. The diorite is the dominant rock for about one hundred feet, but a few small masses of schist also occur
Foliation dip 45°W
Small pegmatite lenses and knots in biotite schist Rock is soft and wet
Foliation dip 36°W
Flaky biotite type of schist Much banded injection
Foliation dip 42°W
Biotite schist Pegmatite bands. Foliation dip 30°W
Banded injection.
—1185+00
Minor joints at right angles to foliation
CONTACT
MONSON GRANODIORITE
BRIMFIELD-WARE SCHIST
NORTH
FLOOR PLAN
SOUTH
80 N60E
70 N56E
30 N41E
65 N41E
70 N56E
75 N40E
LOCATION AND DESCRIPTION OF SPECIMEN
—1190+00 Foliated gray granite with hornblende diorite bands
—1189+50 Granitized biotite schist with pegmatite
—1189+00 Massive hornblende diorite
—1188+50 Pegmatite with biotite folia.
—1188+00 Garnetiferous biotite schist and pegmatite
—1187+50 Granitized biotite schist and pegmatite
—1187+00 Garnetiferous biotite schist and pegmatite
—1186+50 Granitized biotite schist.
—1186+00 Biotite schist with pegmatite streaks.
—1185+50 Garnetiferous granitized schist and pegmatite
—1185+00 Coarse banded garnetiferous granite
N
GEOLOGIC SECTION NORTH WALL
—1185
Pegmatite and coarse granite bands
Foliation dip 35°W
Biotite injection schist
Foliation dip 40°W
Pegmatite lenses and feldspar knots.
Injection gneiss
Foliation dip 32°W
Foliation dip 57°W
Dense biotite schist Foliation dip 30°W
Feldspar knots and lenses
Narrow pegmatite bands
Coarse granite and pegmatite
Foliation dip 24°W Banded injection
Foliation Strike N0°E Dip 30°W
—1180
NORTH
FLOOR PLAN
SOUTH
N88E 83
N74E
N56E 60
85 N88E
N88E 90
90
LOCATION AND DESCRIPTION OF SPECIMEN
—1185+00 Coarse banded garnetiferous granite
—1184+50 Granitized schist
—1184+00 Biotite schist with pegmatite and garnet
—1183+50 Granitized schist
—1183+00 Biotite schist with pegmatite
—1182+50 Biotite schist with pegmatite streaks
—1182+00 Garnetiferous biotite schist with pegmatite lenses
—1181+50 Biotite schist with feldspar crystals and pegmatite
—1181+00 Garnetiferous biotite schist with pegmatite
—1180+50 Biotite schist with feldspar crystals
—1180+00 Biotite injection schist
LEGEND
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PEGMATITE
DIORITE
Tunnel S83°03'W
Dip Degrees Approx
Strike Bearing Degrees
JOINTS
20 10 0 20 40FT

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

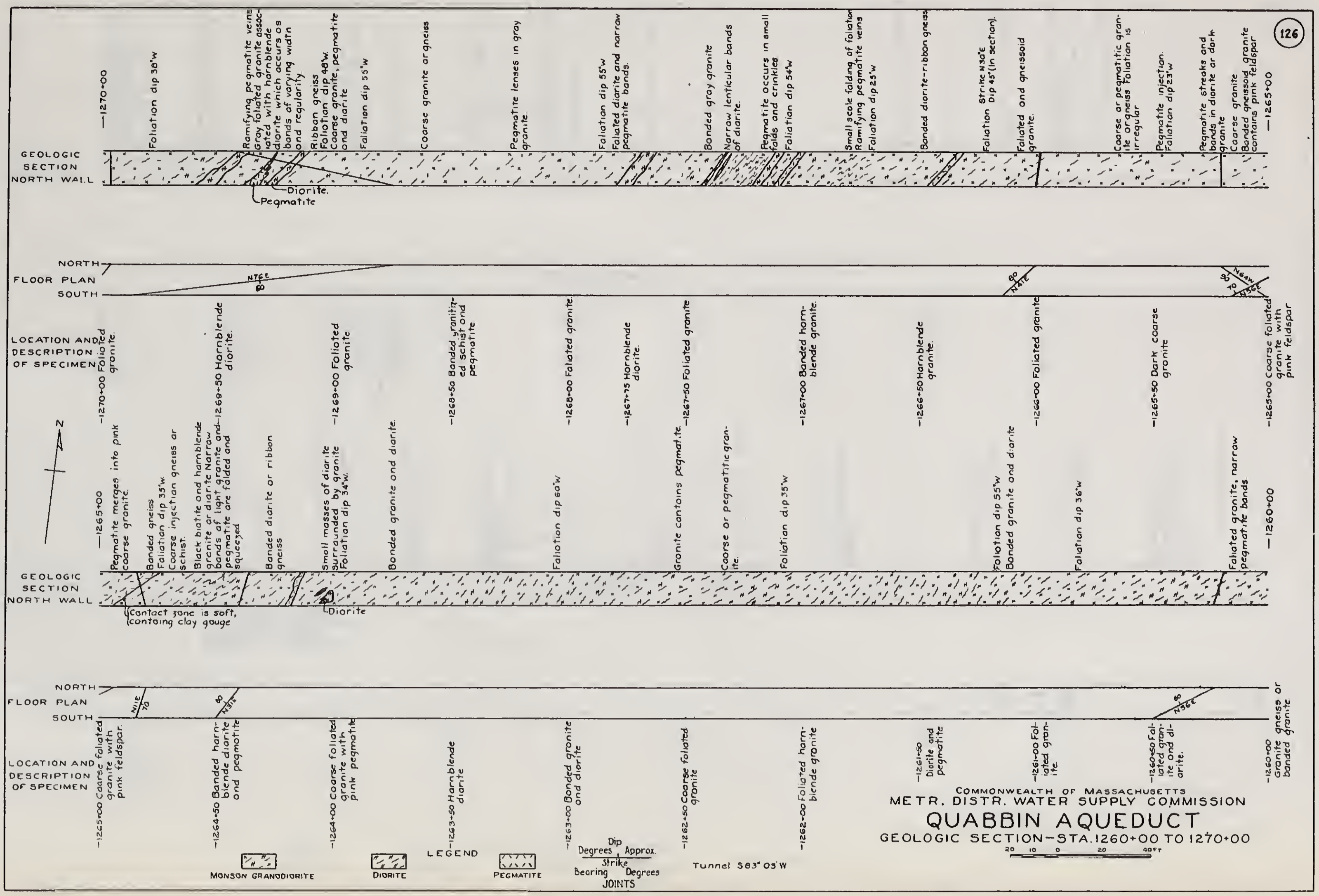
QUABBIN AQUEDUCT

GEOLOGIC SECTION - STA-1180+00 TO 1190+00


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION - STA-1180+00 TO 1190+00
118
GEOLOGIC SECTION NORTH WALL
FLOOR PLAN
NORTH
SOUTH
LOCATION AND DESCRIPTION OF SPECIMEN
— 1190
Bands of gray granite, pegmatite and diorite
Foliation dip 36°W
Pegmatite injection in branching veins. Hornblendic rock (diorite) occurs in bands together with foliated granite
Foliation dip 37°W
A massive diorite contacts the soft schist here. The contact rock occurs as a band about five feet thick and is followed by gray granite. The diorite is the dominant rock for about one hundred feet, but a few small masses of schist also occur
Foliation dip 45°W
Small pegmatite lenses and knots in biotite schist Rock is soft and wet.
Foliation dip 36°W.
Flaky biotite type of schist Much banded injection.
Foliation dip 42°W
Biotite schist Pegmatite bands
Foliation dip 30°W
Banded injection
— 1185+00
Minor joints at right angles to foliation
MONSON GRANODIORITE
CONTACT
BRIMFIELD-WARE SCHIST
80 N60E
70 N56E
70 N41E
65 N41E
70 N56E
75 N40E
—1190+00 Foliated gray granite with hornblende diorite bands
—1189+50 Granitized biotite schist with pegmatite.
—1189+00 Massive hornblende diorite
—1188+50 Pegmatite with biotite folia.
—1188+00 Garnetiferous biotite schist and pegmatite
—1187+50 Granitized biotite schist and pegmatite.
—1187+00 Garnetiferous biotite schist and pegmatite
—1186+50 Granitized biotite schist.
—1186+00 Biotite schist with pegmatite streaks.
—1185+50 Garnetiferous granitized schist and pegmatite
—1185+00 Coarse banded garnetiferous granite
N
— 1185
Pegmatite and coarse granite bands
Foliation dip 35°W
Biotite injection schist
Foliation dip 40°W
Pegmatite lenses and feldspar knots.
Injection gneiss
Foliation dip 32°W
Foliation dip 57°W
Dense biotite schist. Foliation dip 30°W
Feldspar knots and lenses
Narrow pegmatite bands.
Coarse granite and pegmatite
Foliation dip 24°W
Banded injection
Foliation Strike N0°E Dip 30°W
— 1180
N88E 85
N36E
N36E 60
65 N88E
N88E 90
90
—1185+00 Coarse banded garnetiferous granite
—1184+50 Granitized schist
—1184+00 Biotite schist with pegmatite and garnet
—1183+50 Granitized schist
—1183+00 Biotite schist with pegmatite
—1182+50 Biotite schist with pegmatite streaks
—1182+00 Garnetiferous biotite schist with pegmatite lenses
—1181+50 Biotite schist with feldspar crystals and pegmatite
—1181+00 Garnetiferous biotite schist with pegmatite
—1180+50 Biotite schist with feldspar crystals
—1180+00 Biotite injection schist
LEGEND
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PEGMATITE
DIORITE
Tunnel S83° 03'W
Dip Degrees Approx.
Strike
Bearing Degrees
JOINTS
20 10 0 20 40 FT


COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA 1250+00 TO 1260+00

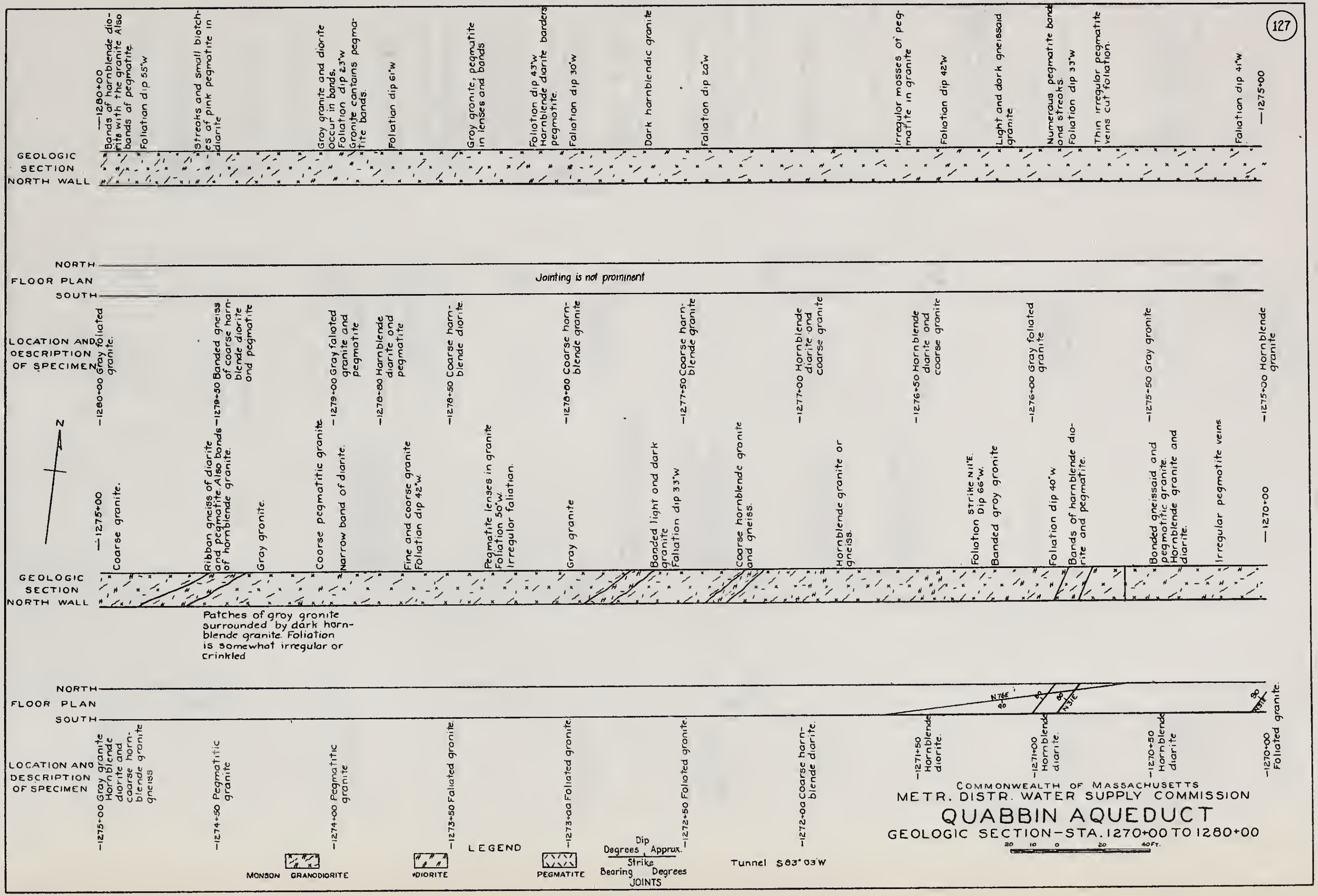
GEOLOGIC SECTION NORTH WALL
—1260+00
Gray foliated granite
Pegmatite occurs in narrow bands
Foliation dip 30°W
Coarse or pegmatitic granite.
Lenticular block of diorite
Blocks of diorite
Foliation dip 35°W
Gray foliated granite.
Banded dark and light gray granite.
Foliation dip 42°W.
Foliation dip 38°W.
Minor folding of foliation structure
Foliated gray granite and narrow diorite bands
Foliation dip 38°W
Ribbon gneiss of granite and diorite
Foliation dip 29°W
Banded granite and diorite.
Pegmatite lens containing pink feldspar
Foliation dip 44°W
Diorite occurs in form of lens. Pegmatite bands and foliation of surrounding granite appear to bend around lens
Foliation dip 38W
Ribbon gneiss of granite and diorite
Foliation dip 43°W
Diorite
—1255+00
NORTH
FLOOR PLAN
SOUTH
A feature of this section is the lack of jointing
65
N76E
LOCATION AND DESCRIPTION OF SPECIMEN
—1260+00 Granite gneiss or banded granite.
—1259+50 Foliated granite.
—1259+00 Foliated granite.
—1258+50 Foliated granite.
—1258+00 Diorite with pegmatite bands
—1257+50 Gray granite and pegmatite
—1257+00 Banded diorite
—1256+50 Banded diorite and granite
—1256+00 Foliated granite
—1255+50 Hornblende diorite and granite
—1255+00 Foliated granite.
N
—1255+00
Foliation dip 36°W.
Foliated and banded granite
Hornblende diorite
Ribbon gneiss of diorite and granite
Diorite surrounded by coarse pegmatitic granite
Alternate bands of hornblende diorite and granite
Foliation dip 35°W.
Coarse foliated gray granite
Foliation dip 41°W.
Some diorite bands appear to be cut off by pegmatitic granite
Largely a coarse granite surrounding block-like masses of diorite.
Foliation dip 37°W
Banded granite.
Foliation dip 20°W
Largely diorite with granite bands and pegmatite.
Irregular pegmatite bands and veins oriented nearly vertical.
—1250+00
GEOLOGIC SECTION NORTH WALL
NORTH
FLOOR PLAN
SOUTH
A feature of this section is the lack of jointing
LOCATION AND DESCRIPTION OF SPECIMEN
—1255+00 Foliated granite
—1254+50 Foliated granite.
—1254+00 Coarse banded diorite
—1253+50 Hornblende diorite
—1253+00 Foliated granite
—1252+50 Coarse granite.
—1252+00 Foliated granite.
—1251+50 Foliated granite.
—1251+00 Foliated granite.
—1250+50 Coarse hornblende diorite.
—1250+00 Banded diorite and granite (Ribbon gneiss)
LEGEND
MONSON GRANODIORITE
DIORITE
PEGMATITE
Dip
Degrees Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S83°03'W
20 10 0 20 40FT


GEOLOGIC SECTION NORTH WALL
—1270+00
Foliation dip 38°W
Ramifying pegmatite veins
Gray foliated granite associated with hornblende diorite which occurs as bands of varying width and regularity
Ribbon gneiss
Foliation dip 48°W
Coarse granite, pegmatite and diorite
Foliation dip 55°W
Coarse granite or gneiss
Pegmatite lenses in gray granite.
Foliation dip 55°W
Foliated diorite and narrow pegmatite bands.
Banded gray granite
Narrow lenticular bands of diorite.
Pegmatite occurs in small folds and crinkles
Foliation dip 54°W
Small scale folding of foliation
Ramifying pegmatite veins
Foliation dip 25°W
Banded diorite-ribbon gneiss
Foliation Strike N30°E Dip 45°(in section).
Foliated and gneissoid granite.
Coarse or pegmatitic granite or gneiss foliation is irregular
Pegmatite injection.
Foliation dip 23°W
Pegmatite streaks and bands in diorite or dark granite
Coarse granite
Banded gneissoid granite contains pink feldspar
—1265+00
Diorite.
Pegmatite
NORTH
FLOOR PLAN
SOUTH
N76E
60
90
N41E
N64W
80
70
N36E
LOCATION AND DESCRIPTION OF SPECIMEN
-1270+00 Foliated granite.
-1269+50 Hornblende diorite.
-1269+00 Foliated granite
-1268+50 Banded granitized schist and pegmatite
-1268+00 Foliated granite.
-1267+75 Hornblende diorite.
-1267+50 Foliated granite
-1267+00 Banded hornblende granite.
-1266+50 Hornblende granite.
-1266+00 Foliated granite
-1265+50 Dark coarse granite
-1265+00 Coarse foliated granite with pink feldspar
N
—1265+00
Pegmatite merges into pink coarse granite.
Banded gneiss
Foliation dip 35°W
Coarse injection gneiss or schist.
Black biotite and hornblende granite or diorite Narrow bands of light granite and pegmatite are folded and squeezed
Banded diorite or ribbon gneiss
Small masses of diorite surrounded by granite
Foliation dip 34°W.
Banded granite and diorite.
Foliation dip 60°W
Granite contains pegmatite
Coarse or pegmatitic granite.
Foliation dip 35°W
Foliation dip 55°W
Banded granite and diorite
Foliation dip 36°W
Foliated granite, narrow pegmatite bands
—1260+00
GEOLOGIC SECTION NORTH WALL
Contact zone is soft, contains clay gouge
Diorite
NORTH
FLOOR PLAN
SOUTH
N11E
70
80
N31E
80
N36E
LOCATION AND DESCRIPTION OF SPECIMEN
-1265+00 Coarse foliated granite with pink feldspar.
-1264+50 Banded hornblende diorite and pegmatite
-1264+00 Coarse foliated granite with pink pegmatite
-1263+50 Hornblende diorite
-1263+00 Banded granite and diorite
-1262+50 Coarse foliated granite
-1262+00 Foliated hornblende granite
-1261+50 Diorite and pegmatite
-1261+00 Foliated granite.
-1260+50 Foliated granite and diorite.
-1260+00 Granite gneiss or banded granite
LEGEND
MONSON GRANODIORITE
DIORITE
PEGMATITE
Dip Degrees Approx. Strike Bearing Degrees
JOINTS
Tunnel S83° 03' W
20 10 0 20 40FT

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

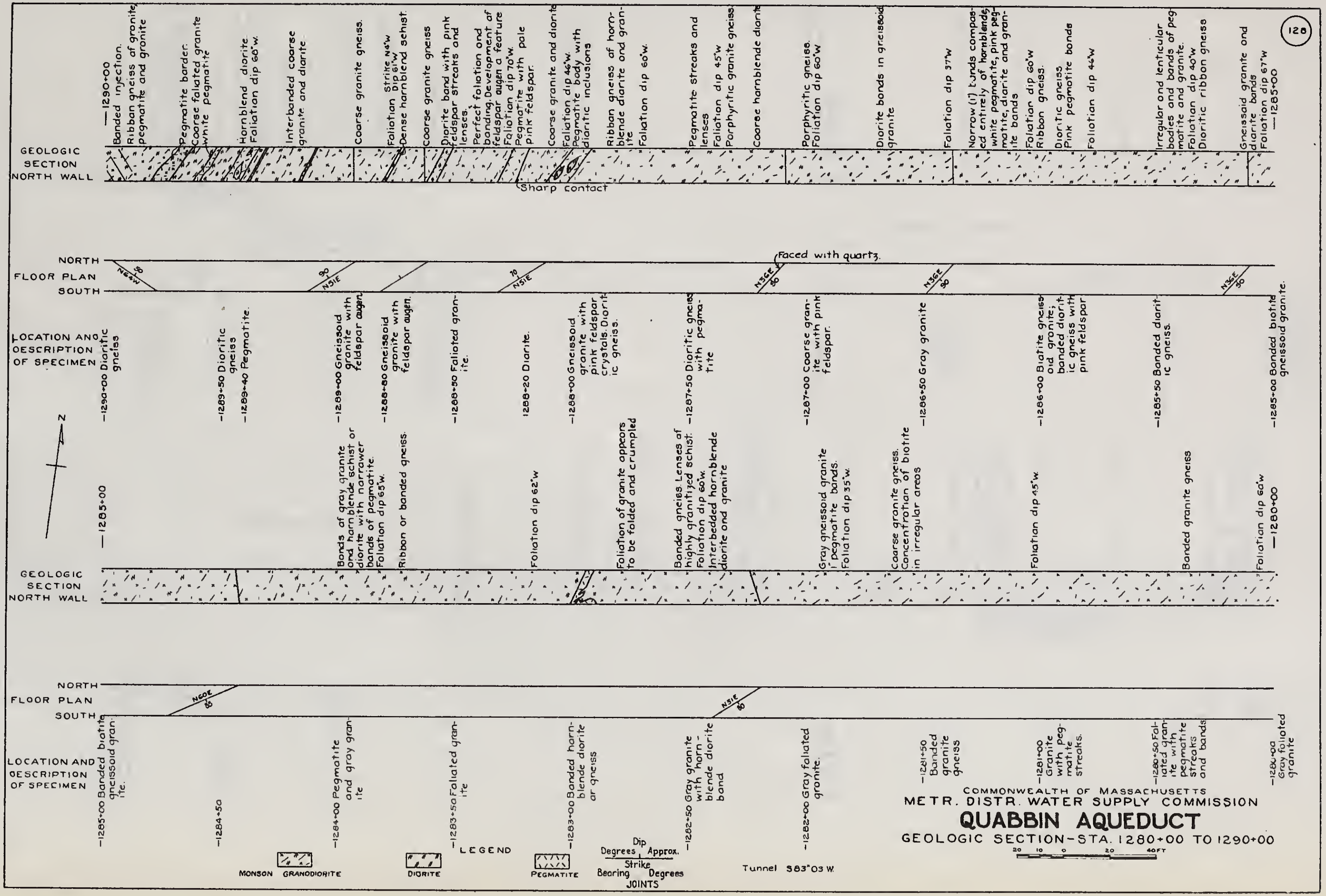
GEOLOGIC SECTION—STA. 1260+00 TO 1270+00


GEOLOGIC SECTION NORTH WALL
—1280+00
Bands of hornblende diorite with the granite Also bands of pegmatite.
Foliation dip 55°W
Streaks and small blotches of pink pegmatite in diorite
Gray granite and diorite occur in bands.
Foliation dip 23°W
Granite contains pegmatite bands.
Foliation dip 61°W
Gray granite, pegmatite in lenses and bands
Foliation dip 43°W
Hornblende diorite borders pegmatite.
Foliation dip 30°W
Dark hornblendic granite
Foliation dip 20°W
Irregular masses of pegmatite in granite
Foliation dip 42°W
Light and dark gneissoid granite
Numerous pegmatite bands and streaks.
Foliation dip 33°W
Thin irregular pegmatite veins cut foliation.
Foliation dip 41°W
—1275+00
NORTH
FLOOR PLAN
SOUTH
Jointing is not prominent
LOCATION AND DESCRIPTION OF SPECIMEN
—1280+00 Gray foliated granite.
—1279+50 Banded gneiss of coarse hornblende diorite and pegmatite
—1279+00 Gray foliated granite and pegmatite
—1278+80 Hornblende diorite and pegmatite
—1278+50 Coarse hornblende diorite.
—1278+00 Coarse hornblende granite
—1277+50 Coarse hornblende granite
—1277+00 Hornblende diorite and coarse granite
—1276+50 Hornblende diorite and coarse granite
—1276+00 Gray foliated granite
—1275+50 Gray granite
—1275+00 Hornblende granite
N
—1275+00
Coarse granite.
Ribbon gneiss of diorite and pegmatite. Also bands of hornblende granite.
Gray granite.
Coarse pegmatitic granite
Narrow band of diorite.
Fine and coarse granite
Foliation dip 42°W.
Pegmatite lenses in granite
Foliation 50°W.
Irregular foliation.
Gray granite
Banded light and dark granite
Foliation dip 33°W
Coarse hornblende granite and gneiss.
Hornblende granite or gneiss.
Foliation strike N11°E. Dip 66°W.
Banded gray granite
Foliation dip 40°W
Bands of hornblende diorite and pegmatite.
Banded gneissoid and pegmatitic granite.
Hornblende granite and diorite.
Irregular pegmatite veins
—1270+00
GEOLOGIC SECTION NORTH WALL
Patches of gray granite surrounded by dark hornblende granite. Foliation is somewhat irregular or crinkled
NORTH
FLOOR PLAN
SOUTH
N76E
90
80
80
N31E
90
N31E
LOCATION AND DESCRIPTION OF SPECIMEN
—1275+00 Gray granite Hornblende diorite and coarse hornblende granite gneiss
—1274+50 Pegmatitic granite
—1274+00 Pegmatitic granite
—1273+50 Foliated granite.
—1273+00 Foliated granite.
—1272+50 Foliated granite.
—1272+00 Coarse hornblende diorite.
—1271+50 Hornblende diorite.
—1271+00 Hornblende diorite.
—1270+50 Hornblende diorite
—1270+00 Foliated granite.
LEGEND
MONSON GRANODIORITE
DIORITE
PEGMATITE
Dip
Degrees, Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S83° 03'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

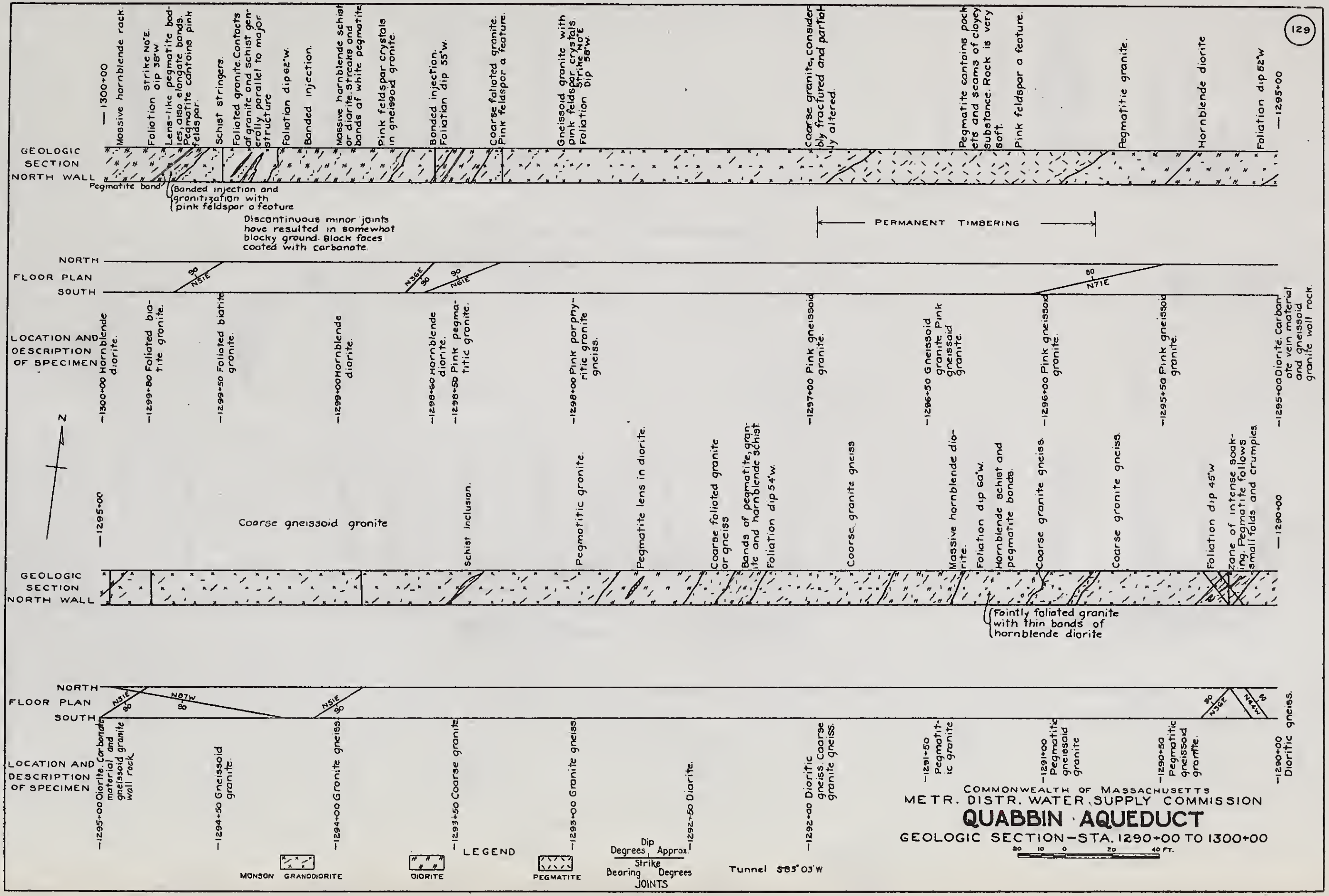
GEOLOGIC SECTION—STA. 1270+00 TO 1280+00


GEOLOGIC SECTION NORTH WALL
—1290+00
Banded injection.
Ribbon gneiss of granite, pegmatite and granite
Pegmatite border.
Coarse foliated granite white pegmatite
Hornblend diorite
Foliation dip 68°W.
Interbanded coarse granite and diorite
Coarse granite gneiss.
Foliation Strike N4°W Dip 61°W
Dense hornblend schist.
Coarse granite gneiss
Diorite band with pink feldspar streaks and lenses.
Perfect foliation and banding. Development of feldspar augen a feature
Foliation dip 70°W.
Pegmatite with pale pink feldspar.
Sharp contact
Coarse granite and diorite
Foliation dip 46°W.
Pegmatite body with dioritic inclusions
Ribbon gneiss of hornblende diorite and granite
Foliation dip 60°W.
Pegmatite streaks and lenses
Foliation dip 45°W
Porphyritic granite gneiss.
Coarse hornblende diorite
Porphyritic gneiss.
Foliation dip 60°W
Diorite bands in gneissoid granite
Foliation dip 37°W
Narrow (1') bands composed entirely of hornblende, white pegmatite, pink pegmatite, diorite and granite bands
Foliation dip 60°W
Ribbon gneiss.
Dioritic gneiss
Pink pegmatite bands
Foliation dip 44°W
Irregular and lenticular bodies and bands of pegmatite and granite.
Foliation dip 40°W
Dioritic ribbon gneiss
Gneissoid granite and diorite bands
Foliation dip 67°W
—1285+00
NORTH
FLOOR PLAN
SOUTH
N64°W 38
90 N51E
70 N51E
N36E 90
Faced with quartz.
N36E 90
N36E 90
LOCATION AND DESCRIPTION OF SPECIMEN
—1290+00 Dioritic gneiss
—1289+50 Dioritic gneiss
—1289+40 Pegmatite.
—1289+00 Gneissoid granite with feldspar augen.
—1288+80 Gneissoid granite with feldspar augen.
—1288+50 Foliated granite.
1288+20 Diorite.
—1288+00 Gneissoid granite with pink feldspar crystals. Dioritic gneiss.
—1287+50 Dioritic gneiss with pegmatite
—1287+00 Coarse granite with pink feldspar.
—1286+50 Gray granite
—1286+00 Biotite gneissoid granite; banded dioritic gneiss with pink feldspar
—1285+50 Banded dioritic gneiss.
—1285+00 Banded biotite gneissoid granite.
N
—1285+00
Bands of gray granite and hornblende schist or diorite with narrower bands of pegmatite.
Foliation dip 65°W.
Ribbon or banded gneiss.
Foliation dip 62°W
Foliation of granite appears to be folded and crumpled
Banded gneiss. Lenses of highly granitized schist.
Foliation dip 60°W.
Interbedded hornblende diorite and granite
Gray gneissoid granite 1' pegmatite bands.
Foliation dip 35°W.
Coarse granite gneiss.
Concentration of biotite in irregular areas
Foliation dip 45°W.
Banded granite gneiss
Foliation dip 60°W
—1280+00
GEOLOGIC SECTION NORTH WALL
NORTH
FLOOR PLAN
SOUTH
N60E 85
N51E 80
LOCATION AND DESCRIPTION OF SPECIMEN
—1285+00 Banded biotite gneissoid granite.
—1284+50
—1284+00 Pegmatite and gray granite
—1283+50 Foliated granite
—1283+00 Banded hornblende diorite or gneiss
—1282+50 Gray granite with hornblende diorite band
—1282+00 Gray foliated granite.
—1281+50 Banded granite gneiss
—1281+00 Granite with pegmatite streaks.
—1280+50 Foliated granite with pegmatite streaks and bands
—1280+00 Gray foliated granite
LEGEND
MONSON GRANODIORITE
DIORITE
PEGMATITE
Dip Degrees Approx.
Strike
Bearing Degrees
JOINTS
Tunnel S83°03 W.
20 10 0 20 40FT

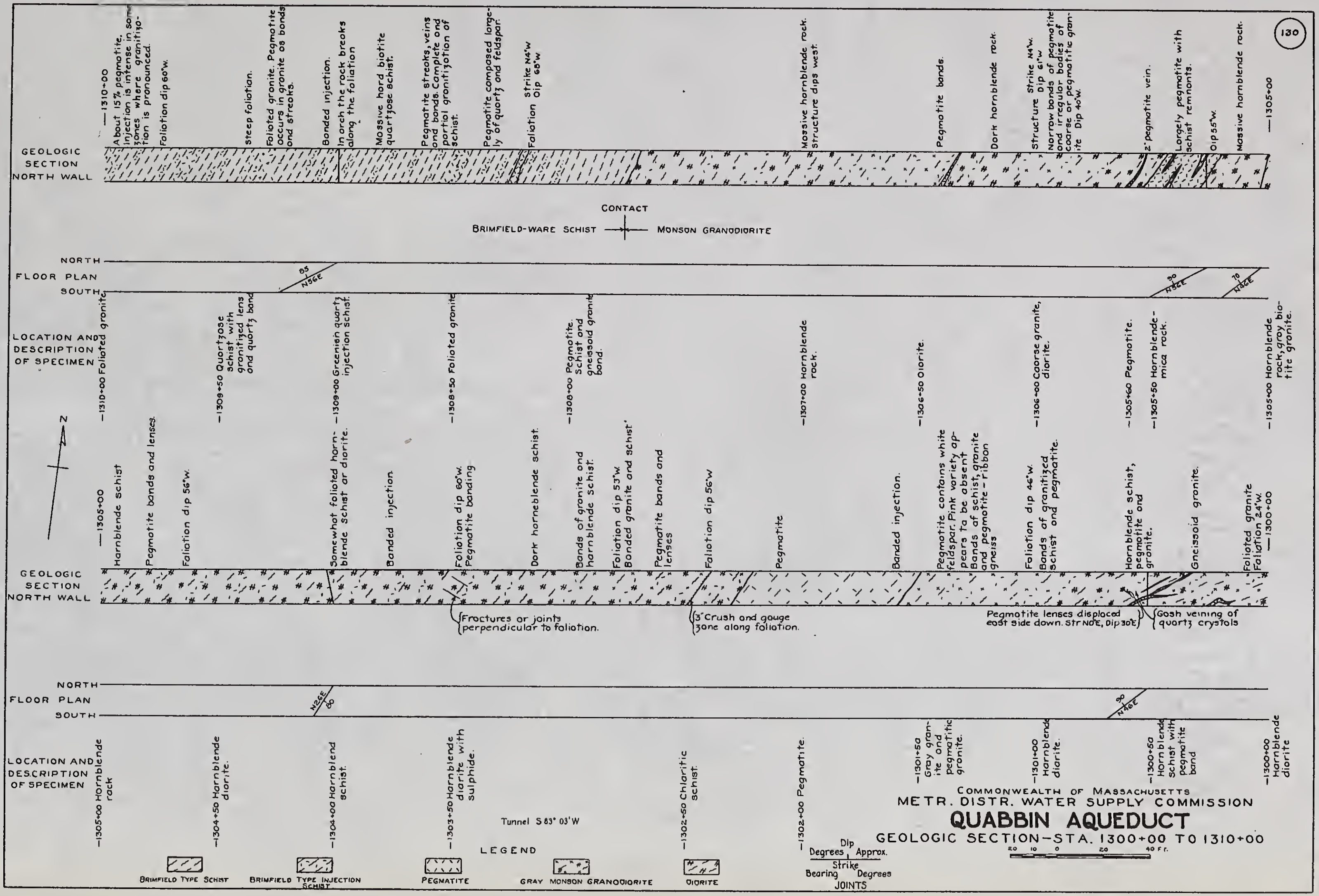
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION–STA. 1280+00 TO 1290+00


GEOLOGIC SECTION NORTH WALL
1300+00
Massive hornblende rock.
Foliation strike N0°E. dip 38°W
Lens-like pegmatite bodies, also elongate bands. Pegmatite contains pink feldspar.
Schist stringers.
Foliated granite. Contacts of granite and schist generally parallel to major structure
Foliation dip 62°W.
Banded injection.
Massive hornblende schist or diorite. Streaks and bands of white pegmatite.
Pink feldspar crystals in gneissoid granite.
Banded injection. Foliation dip 55°W.
Coarse foliated granite. Pink feldspar a feature.
Gneissoid granite with pink feldspar crystals Foliation Strike N0°E Dip 58°W.
Coarse granite, considerably fractured and partially altered.
Pegmatite contains pockets and seams of clayey substance. Rock is very soft.
Pink feldspar a feature.
Pegmatitic granite.
Hornblende diorite
Foliation dip 52°W
1295+00
Pegmatite band
Banded injection and granitization with pink feldspar a feature
Discontinuous minor joints have resulted in somewhat blocky ground. Block faces coated with carbonate.
PERMANENT TIMBERING
NORTH
FLOOR PLAN
SOUTH
90 N51E
N36E 90
90 N61E
80 N71E
LOCATION AND DESCRIPTION OF SPECIMEN
1300+00 Hornblende diorite.
1299+80 Foliated biotite granite.
1299+50 Foliated biotite granite.
1299+00 Hornblende diorite.
1298+60 Hornblende diorite.
1298+50 Pink pegmatitic granite.
1298+00 Pink porphyritic granite gneiss.
1297+00 Pink gneissoid granite.
1296+50 Gneissoid granite Pink gneissoid granite.
1296+00 Pink gneissoid granite.
1295+50 Pink gneissoid granite.
1295+00 Diorite. Carbonate vein material and gneissoid granite wall rock.
N
GEOLOGIC SECTION NORTH WALL
1295+00
Coarse gneissoid granite
Schist inclusion.
Pegmatitic granite.
Pegmatite lens in diorite.
Coarse foliated granite or gneiss
Bands of pegmatite, granite and hornblende schist Foliation dip 54°W.
Coarse granite gneiss
Massive hornblende diorite.
Foliation dip 60°W.
Hornblende schist and pegmatite bands.
Coarse granite gneiss.
Coarse granite gneiss.
Foliation dip 45°W
Zone of intense soaking. Pegmatite follows small folds and crumples.
1290+00
Faintly foliated granite with thin bands of hornblende diorite
NORTH
FLOOR PLAN
SOUTH
N51E 90
N87W 90
N51E 90
90 N36E
N44W 85
LOCATION AND DESCRIPTION OF SPECIMEN
1295+00 Diorite. Carbonate material and gneissoid granite wall rock.
1294+50 Gneissoid granite.
1294+00 Granite gneiss.
1293+50 Coarse granite
1293+00 Granite gneiss.
1292+50 Diorite.
1292+00 Dioritic gneiss. Coarse granite gneiss.
1291+50 Pegmatitic granite
1291+00 Pegmatitic gneissoid granite
1290+50 Pegmatitic gneissoid granite.
1290+00 Dioritic gneiss.
LEGEND
MONSON GRANODIORITE
DIORITE
PEGMATITE
Dip Degrees Approx. Strike Bearing Degrees JOINTS
Tunnel S83°03'W
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
QUABBIN AQUEDUCT
GEOLOGIC SECTION—STA. 1290+00 TO 1300+00


130
GEOLOGIC SECTION NORTH WALL
—1310+00
About 15% pegmatite. Injection is intense in some zones where granitization is pronounced.
Foliation dip 60°W.
Steep foliation.
Foliated granite. Pegmatite occurs in granite as bands and streaks.
Banded injection.
In arch the rock breaks along the foliation
Massive hard biotite quartzose schist.
Pegmatite streaks, veins and bands. Complete and partial granitization of schist.
Pegmatite composed largely of quartz and feldspar.
Foliation Strike N4°W Dip 68°W
Massive hornblende rock. Structure dips west.
Pegmatite bands.
Dark hornblende rock.
Structure Strike N4°W. Dip 61°W
Narrow bands of pegmatite and irregular bodies of coarse or pegmatitic granite Dip 40°W.
2' pegmatite vein.
Largely pegmatite with schist remnants.
Dip 55°W.
Massive hornblende rock.
—1305+00
CONTACT
BRIMFIELD-WARE SCHIST
MONSON GRANODIORITE
NORTH
FLOOR PLAN
SOUTH
85
N56E
90
N56E
70
N46E
LOCATION AND DESCRIPTION OF SPECIMEN
—1310+00 Foliated granite
—1309+50 Quartzose schist with granitized lens and quartz band
—1309+00 Greenish quartz injection schist.
—1308+50 Foliated granite
—1308+00 Pegmatite. Schist and gneissoid granite band.
—1307+00 Hornblende rock.
—1306+50 Diorite.
—1306+00 Coarse granite, diorite.
—1305+60 Pegmatite.
—1305+50 Hornblende-mica rock.
—1305+00 Hornblende rock, gray biotite granite.
N
GEOLOGIC SECTION NORTH WALL
—1305+00
Hornblende schist
Pegmatite bands and lenses.
Foliation dip 56°W.
Somewhat foliated hornblende schist or diorite.
Banded injection.
Foliation dip 60°W. Pegmatite banding
Dark hornblende schist.
Bands of granite and hornblende schist.
Foliation dip 53°W. Banded granite and schist'
Pegmatite bands and lenses
Foliation dip 56°W
Pegmatite
Banded injection.
Pegmatite contains white feldspar. Pink variety appears to be absent
Bands of schist, granite and pegmatite - ribbon gneiss
Foliation dip 46°W.
Bands of granitized schist and pegmatite.
Hornblende schist, pegmatite and granite.
Gneissoid granite.
Foliated granite Foliation 24°W.
—1300+00
Fractures or joints perpendicular to foliation.
3" Crush and gouge zone along foliation.
Pegmatite lenses displaced east side down. Str N0E, Dip 30E
Gash veining of quartz crystals
NORTH
FLOOR PLAN
SOUTH
N26E
80
90
N46E
LOCATION AND DESCRIPTION OF SPECIMEN
—1305+00 Hornblende rock
—1304+50 Hornblende diorite.
—1304+00 Hornblend schist.
—1303+50 Hornblende diorite with sulphide.
—1302+50 Chloritic schist.
—1302+00 Pegmatite.
—1301+50 Gray granite and pegmatitic granite.
—1301+00 Hornblende diorite.
—1300+50 Hornblende schist with pegmatite band
—1300+00 Hornblende diorite
Tunnel S 83° 03'W
LEGEND
BRIMFIELD TYPE SCHIST
BRIMFIELD TYPE INJECTION SCHIST
PEGMATITE
GRAY MONSON GRANODIORITE
DIORITE
Dip
Degrees Approx.
Strike
Bearing Degrees
JOINTS
20 10 0 20 40 FT.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

QUABBIN AQUEDUCT

GEOLOGIC SECTION—STA. 1300+00 TO 1310+00